A Seybert

EXPERIMENTAL RESEARCHES

CONCERNING THE

PHILOSOPHY

OF

PERMANENT COLOURS;

AND THE

BEST MEANS OF PRODUCING THEM,

BY

DYEING, CALICO PRINTING, &c.

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"Cet art (de la teinture) est un des plus utiles et des plus merveilleux qu'on connoisse; et si *quelque un peut inspirer un noble orgueil à l'homme, c'est celui là:* non seulment il a procuré le moyen de suivre et d'imiter la nature dans la richesse et l'eclat des couleurs; mais il paroit l'avoir surpassé en donnant plus d'éclat, plus de fixité et plus de solidité aux couleurs fugaces et passageres dont elle a revetu tous les corps qui composent ce globe."

CHAPTAL, *Elémens de Chimie*, tom. iii. p. 185.

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PART II.

CONTINUED.

CHAPTER V.

Of the Coccus Ficus, or Coccus Lacca, *and its Nidus, or Comb, commonly called* Lac, Lacca, *or Lácshá*.*

"La chimie des arts ne se borne point à porter son flambeau sur ce qui est connu,
"ou à perfectionner ce qui se pratique: elle crée, chaque jour de nouveaux arts."
CHAPTAL. Chimie appliquée aux arts. Discours préliminaire.

THIS substance was probably unknown in Europe until after the Portuguese had visited India by sailing round the Cape of Good Hope, and very discordant opinions were entertained of it, for a considerable time after its first importation. Cardanus (de subtilitate rerum, lib. viii.) represented lac as a natural gum, exuding from a sort of cherry-tree in India.—But this was contradicted by Amatus Lusitanus, in the first book of his

* Sir William Jones says, "the Hindûs have six names for Lac; "but they generally call it Lácshá, from the multitude of small in- "sects, who, as they believe, discharge it from their stomachs, and "at length destroy the tree on which they form their colonies." Dissertations, &c. relating to the History and Antiquities, &c. of Asia, vol. ii.

annotations upon Dioscorides, where he asserts, that it is the excrement of a species of winged ants in the kingdom of Pegu; which opinion was also delivered by Christopher Acosta, in his treatise de Hist. plant. aromatumque Indiarum Orientalium.

Caneparius, after noticing these opinions, (and others proposed by Garzia ab Horto, Clusius, &c.) endeavoured to convince his readers, that lac was produced by the sap, or juice, of certain trees, wounded by a species of ants, which, by exposure to the air, acquired the hardness of a gum, and retained some of the ants, which, as he supposed, had been caught and entangled therein by its viscidity. He adds, that being boiled, it was employed to give cloths a red colour by dyeing, and that the colouring matter left in the dyeing vessel, being afterwards formed into a mass by evaporation, was called an artificial *lac*, and employed by painters.* He adds, that similar *pigments*, being afterwards prepared from the colouring matters of kermes, Polish cochineal, (or coccus Polonicus) Brasil wood, &c. remaining in the liquors in which cloth and silk had been dyed with these matters, such pigments were called by the Italians lacca, adding to this name that of the substance whence the colour was obtained, as "lacca di verzino (Brasil wood) lacca di *grana*, lacca di cremise," &c., and this explanation enables us to ascertain the origin of the English word *lake*.

A much more correct account of lac, and of the insects producing it, was given by Mr. James Kerr, of Patna, in a communication to the Royal Society, which was published in the Philosophical Transactions for

* "Iccirco coquitur pro tingendis pannis colore rubeo; mox ex ipsius reliquiis post tincturam panni conficitur massa quæ dicitur Lacca artificialis qua utuntur pictores." De Atramentis, &c. p. 214.

1781. By this account it appears, that when the *lac* insect is first brought forth in November and December, "the head and trunk form one uniform oval compressed *red* body, of the shape and magnitude of a very small louse, consisting of twelve transverse rings; the back is carinate, the belly flat, the antennæ half the length of the body, fili-form, truncated, and diverging, sending off two, sometimes three, delicate diverging hairs longer than the antennæ." The tail is "a little white point, sending off two horizontal hairs, as long as the body." The insect had three pair of limbs half of its own length, but no wings were seen by Mr. Kerr. As soon as they are brought forth, the insects begin to "traverse the branches of the trees upon which they were produced for some time, and then fix themselves upon the succulent extremities of the young branches. By the middle of January they are all fixed in their proper situations, and appear as plump as before, but show no other marks of life. The limbs, antennæ, and setæ of the tail, are no longer to be seen. Around their edges they are environed with a spissated subpellucid liquid, which seems to glue them to the branch. It is the gradual accumulation of this liquid which forms a complete cell for each insect, and is what is called gum lacca. About the middle of March the cells are completely formed, and the insect is in appearance an oval smooth red bag, without life, about the size of a small cuchanical insect, emarginated at the obtuse end, full of a beautiful *red liquid*. In October and November we find about twenty or thirty oval eggs, or rather young grubs, within the red fluid of the mother. When this fluid is all expended, the young insects pierce a hole through the back of their mother, and walk off one by one, leaving their exuviæ behind."

According to Mr. Kerr, the lacca insects in the

country where he wrote, were found in four species of shrubs: first, Ficus Religiosa, Linn.; second, Ficus Indica, Linn.; third, Plaso Hortus Malabaraci; and, fourth, Rhamnus Jujuba, Linn.—They fix themselves in such multitudes on these trees, and more especially of the three first, that "the extreme branches appear as if they were covered by a red dust; and their sap is so much exhausted, that they wither and produce no fruit." Birds perching on these branches carry off great numbers of the lacca insects, adhering to their feet, and transplant, by depositing them, on other trees where they rest.

"The gum lacca of this country (says Mr. Kerr) is principally found upon the uncultivated mountains on both sides of the Ganges, where bountiful nature has produced it in such abundance, that were the consumption ten times greater than it is, the markets might be supplied by this minute insect. The only trouble in procuring the lac is in breaking down the branches, and carrying them to market. The present price in Dacca is about 12*s.* the 100lbs. weight, although it is brought from the distant country of Assam. The best lac is of a *deep red* colour. If it be pale, and pierced at the top, the value diminishes, because the insects have left their cells, and consequently they can be of no use as a dye or colour," though the lac itself may be better for varnishes.

The lacca is capable of being applied to several uses. That of dyeing, however, is alone the object of our present inquiry; and for this it is supposed to have been known and employed by the ancients; but this cannot be ascertained, because they have left no description of it sufficiently accurate. (See Salmas. Exercit. p. 810.)

By Mr. Kerr's account, the native Indian inhabitants, after extracting the colouring matter of the lac by hot

water, mix alum and tamarind water with the decoction, and dye silk and cotton therein.

A further account of the lac insect was, a few years afterwards, communicated to the Royal Society, by Mr. Robert Saunders, and published in the Philosophical Transactions for 1789, of which the following are extracts, *viz.*

" Lac is known in Europe by the different appellations of *stick* lac, *seed* lac, and *shell* lac. The first is the lac in pretty considerable lumps, with much of the woody parts of the branches on which it is formed adhering to it.* *Seed* lac is only the stick lac broke into small peices, garbled and appearing in a granulated form.† *Shell* lac is the purified lac by a very simple process, to be mentioned afterwards.‡

* *Stick* lac is properly the lac in its *natural state*, adhering to, and often completely surrounding, for five or six inches, the *twigs* on which it is produced by the insects contained in its cells. When the twigs or sticks are large, and only partially covered, the lac is frequently separated from the sticks, as, indeed, it ought always to be when shipped for Europe, to avoid paying freight uselessly for the latter. Sometimes pieces of lac, with or without the twigs, after having been exposed to great heat from the sun, cohere and form lumps.

† This account of seed lac is very incorrect. When *lac* has been separated from the twigs to which it naturally adheres, and coarsely pounded, the silk and cotton dyers extract the colour, as far as it can conveniently be done, by water; after which the yellowish *hard resinous* powder, in appearance somewhat resembling mustard seed, is called *seed* lac. I have compared samples of seed lac as imported and deposited in the warehouses of the India Company, with powdered stick lac, treated in the way just described, for my own experiments, and have found *both to be exactly similar* in appearance and in the fact of their containing but a small, and nearly an equal *remnant* of colouring matter.

‡ *Shell* lac is produced from *seed* lac, by putting the latter into long cylindrical bags of cotton cloth, and melting it, by holding the bags over a charcoal fire, and when the lac melts, straining or

"The tree on which this fly most commonly generates, is known in Bengal by the name of the biher tree, and is a species of the rhamnus.* The fly is nourished by the tree, and there deposits its eggs, which nature has provided it with the means of defending from external injury by a collection of this lac, evidently serving the two-fold purpose of a nidus and covering to the ovum and insect in its first stage, and food for the maggot in its more advanced state. The lac is formed into complete cells, finished with as much regularity and art as a honey-comb, but differently arranged. The flies are invited to deposit their eggs on the branches of the tree, by besmearing them with some of the fresh lac, steeped in water, which attracts the fly, and gives a better and larger crop.

"The lac is collected twice a year, in the months of February and August.

"I have examined the egg of the fly with a very good microscope; it is of a very *pure red*, perfectly transparent, except in the centre, where there were evident marks of the embryo forming, and opaque ramifications passing off from the body of it. The egg is per-

forcing it through the pores of the cloth, by twisting the bags; which is done by two men, one holding each end of a bag. The lac so strained, is made to fall upon the smooth junk of a plantane tree, (*Musa Paradisiaca*) and is there spread into thin plates, or lamellæ. —The resin being the most liquefiable part of the lac, it thus passes, almost exclusively, through the strainer, and in a considerable degree of purity.

Shell lac is principally employed in Europe to compose varnishes and sealing-wax. The latter use of it, was noticed by Garzia ab Horto, in 1563. (See Aromatum et simplicium aliquot Historia, &c.)

* This is a mistake; the biher, or bihar tree, is the croton lacciferum, Linn. which seems to be generally preferred by the lac insects. It is described by Loureiro, Cochinchina, i. p. 582.

fectly oval, and about the size of an ant's egg. The maggot is about one eighth of an inch long, formed of many rings, (ten or twelve) with a small red head; when seen with a microscope, the parts of the head were easily distinguished, with six small specks on the breast, somewhat projecting, which seemed to be the incipient formation of the feet. This maggot is now in my custody, in the form of a nymph, or chrysalis; its annual coat forming a strong covering, from which it should issue forth a fly.

"Nature has provided most insects with the means of secreting a substance which generally answers the two-fold purpose of defending the embryo and supplying nourishment to the insect, from the time of its animation till able to wander abroad in quest of food. The fresh lac contains within its cells a liquid, sweetish to the taste, and of a fine red colour, miscible in water. The natives of Assam use it as a dye, and cotton dipped in in this liquid makes afterwards a very good red ink.

"*Assam* furnishes us with the greatest quantity of lac in use; and it may not be generally known, that the tree on which they produce the best and largest quantity of lac, is not uncommon in Bengal, and might be employed in propagating the fly, and cultivating the lac, to great advantage. The small quantity of lac collected in these provinces, affords a precarious and uncertain crop, because not attended to. Some attention at particular seasons, is necessary to invite the fly to the tree; and collecting the whole of the lac with too great an avidity, where the insect is not very generally to be met with, may annihilate the breed."

Of the four species of shrubs upon which, Mr. Kerr says, the lacca insects are found in the countries adjacent to Patna, there is only one, the rhamnus jujuba, upon which Dr. James Anderson could find them near

Madras, though he observed them on several species of mimosa, and on some other trees and shrubs.

Dr. Roxburgh, indeed, seems to think, that on the coast of Coromandel they only inhabit shrubs of the mimosa kind, and even but three species of this genus. He says, (see Philos. Trans. 1791,) that "some pieces of fresh looking lac adhering to small branches of the mimosa cinerea, Linn. were brought to him on the 20th November, 1789;" and being carefully kept in wide-mouthed crystal bottles, slightly covered, after fourteen days had elapsed " thousands of exceeding minute red " animals were observed crawling about the lac and the branches it adhered to, and still more were adhering to the surface of the cells. By the assistance of glasses, small imperforated excrescences were also observed interspersed among the holes; two regularly to each hole, crowned with some very fine white hairs, which being rubbed off, two white spots appeared. The animals, when single, ran about pretty briskly; but in general, on opening the cells, they were so numerous as to be crowded over one another.

" The substance of which the cells were formed, cannot be better described, (says Dr. Roxburgh,) with respect to appearance, than by saying, that it is like the transparent amber that beads are made of. The external covering of the cells may be about half a line thick, is remarkably strong, and able to resist injuries; the partitions are much thinner. The cells are in general irregular squares, pentagons, and hexagons, about an eighth of an inch in diameter, and a quarter of an inch deep; they have no communication with each other. All those I opened, during the time the animals were issuing from them, contained in one side, which occupied half the cell, a small bag filled with a thick red jelly-like liquor, replete with what I take to be

the eggs. These bags, or utriculi, adhere to the bottom of the cells, and have each two necks, which pass through perforations in the external coat of the shells, forming the beforementioned excrescences, ending in some fine hairs.

"The other half of the cells has a distinct opening, and contains a white substance, like some filaments of cotton rolled together, and a number of the little red insects themselves, crawling about ready to make their exit. Their portion of each cell is about one half, and I think must have contained near one hundred of these animals. Other cells less forward, contained in this half, with one opening, a thick, red, dark, blood-coloured liquor, with numbers of exceedingly minute eggs, many times smaller than those found in the small bags which occupied the other half of the cells."

Dr. Roxburgh describes the circumstances and progress of these insects, and particularly the females, through the larva and pupa onwards, to their perfect states, which last they did not reach until near five months. The male insect in the perfect state was about the size of a very small fly, and exceedingly active; with an obtuse head, black eyes, oval brown trunk, six legs for running and jumping, and four membranaceous incumbent wings, of which the anterior pair was twice as long as the posterior, but he had no tail.

The female insect, in her perfect state, was rather smaller than the male, and of a brighter red colour, though less active. Her head and eyes were very small; trunk red, and almost orbicular; abdomen red, oblong, and composed of twelve annular segments; she had six legs for running and jumping, with only two long transparent incumbent wings, and a tail consisting of two white hairs as long as her body.

"The eggs, and dark-coloured glutinous liquor they

are found in, (continues Dr. Roxburgh,) communicate to water a most beautiful red colour, *while fresh.* After they have been dried the colour they give to water is less bright; it would therefore be well worth while for those who are situated near places where the lac is plentiful, to try to extract and preserve the colouring principles by such means as would prevent them from being injured by keeping. I doubt not but in time a method may be discovered to render this colouring matter as valuable as cochineal.

"Mr. Hellot's process (adds Dr. Roxburgh) for extracting the colouring matter from dry lac, deserves to be tried with the fresh lac, in the month of October or beginning of November, before the insects have acquired life; for I found the deepest and best colour was procured from the eggs while mixed with their nidus. His process is as follows: Let some powdered gum lac be digested two hours in a decoction of comfrey root, by which a fine crimson colour is given to water, and the gum is rendered pale or straw coloured. To this tincture, poured off clear, let a solution of alum be added; and when the colouring matter has subsided, let it be separated from the clear liquor and dried. It will weigh about one-fifth of the quantity of lac employed. This dried fecula is to be dissolved or diffused in warm water; and some solution of tin is to be added to it, by which it acquires a vivid scarlet colour. This liquor is to be added to a solution of tartar in boiling water, and thus the dye is prepared.

"In India (says Dr. Roxburgh) comfrey roots are not to be had; but any other mucilaginous root, gum, or bark, would probably answer equally well. On some parts of the Coromandel coast, if not over it all, a decoction of the seeds of a very common plant, (Cassia Tora of Linnæus,) which is extremely muci-

laginous, is used by the dyers of cotton cloth blue, to help to prepare the blue vat. It *suspends* the indigo until a fermentation takes place to dissolve it, and also helps to bring about that fermentation earlier than it otherwise would."

Probably some methods of extracting the colouring matter of fresh lac, similar perhaps in a considerable degree to that proposed by Dr. Roxburgh, have been already (1793) attempted in some parts of India. A gentleman to whom I have had occasion to allude several times, lately received from Bengal, where he had formerly resided, a parcel of a colouring matter, which had very much the appearance of powdered cochineal, of which he gave me a few ounces, calling it East-Indian Cochineal, with a request that I would try its effects in dyeing scarlet. I happened then to have by me a piece of cloth which I had previously prepared for receiving a scarlet from cochineal, (upon a new principle explained in the preceding chapter,) by impregnating it with a muriatic solution of tin, and a certain portion of yellow colour from the quercitron bark; and I resolved to see whether this East-Indian colouring matter would yield a crimson, capable, when fixed as a dye in the cloth so impregnated and made yellow, of producing a scarlet, as the natural crimson of cochineal would do by the same means. But on boiling the cloth in question with this East-Indian colouring matter, in water, I found it wholly insoluble by this menstruum. However, upon taking out the cloth, and adding a little vegetable alkali, the water immediately assumed a fine crimson colour, the alkali having, as I afterwards discovered, separated the colouring matter from a portion of alumine which had been employed to precipitate it (in India), and to which it was too intimately united to be dissolved by water *only*. Having thus obtained a solu-

tion of the colouring matter in question, I decanted off the clear crimson liquor, added to it a little muriate of tin, principally to neutralize the alkali, and precipitate any alumine which might have been dissolved by it, and then dyed the piece of cloth before mentioned, which took a good scarlet, better indeed than I had been able to give by the lac brought to this country in its natural form; though, from many circumstances and subsequent trials, I am fully persuaded that the colouring matter which produced this effect was in reality nothing but the colouring matter of lac, extracted either when fresh, or by some particular means when dried, and afterwards precipitated either wholly or in part by alum.

A few years since, some persons in this country formed an establishment for extracting the colouring matter of dried stick lac; but it probably did not succeed according to their expectations, since it does not, I believe, now subsist. An extract, answering tolerably well, may be made from this drug, by merely boiling it in water, straining off the coloured liquor, and evaporating it to a solid consistence. The fine red-coloured liquor contained in the cells of the lac is described by some authors as being sweet to the taste, at the same time that it readily mixes with water. Great use is made of it as a dye by the natives of Assam.

The colours dyed by stick lac approach very nearly to those of cochineal. They are indeed not quite so lively and beautiful, but this defect is in some degree compensated by their being more durable, especially on cotton, where I have employed it with some success topically, with different bases. It has been sometimes a practice to employ a mixture of the colouring matter of lac, with that of cochineal, in producing scarlets, &c. Both require the same basis, and nearly the same treat-

ment. At present, however, almost all the stick lac brought to Europe is afterwards sent to Portugal, Barbary, &c., and employed in staining goat skins to produce the red Morocco leather.

Subsequently to, and in consequence of the preceding observations, (first published in 1794,) Mr. Stephens, surgeon to the *East India* Company's establishment at Keerpoy, undertook to prepare an extract of the colouring matter of the lac insect, of which Mr. Fleming, inspector of drugs, to *the board of trade* in Bengal, gave the following account, in his letter to that board, dated July 7th, 1796, *viz.*

"Dr. Bancroft, in a very instructive work which he has lately published on the subject of dyeing, mentions, as a desideratum, a method of extracting the colouring matter of lac, and thinks that if it could be formed into a lake and sent home in that state, it would be a far preferable mode to that of sending the stick lac. Encouraged by so good an authority, I herewith send for your inspection two bottles of a preparation which I have received from Mr. Stephens at Keerpoy, and which appears to me to be exactly what the Doctor desires. Mr. Stephens informs me that he prepared it from *fresh* lac, by a method discovered by himself, and that if it should be found to answer on trial, he will be able to provide a considerable quantity of it every year. I therefore beg leave to recommend, that the accompanying sample may be sent home by the Dart, with a request to the honourable Court of Directors, that it may be forwarded to Dr. Bancroft, for his opinion respecting its value. I have dyed several pieces of kerseymere cloth with it, and was agreeably surprised to find it, even under my inexpert management, to produce so good a colour. I have no doubt that in the hands of a skilful dyer it will bring out as bright and beautiful

a scarlet as the cochineal itself. I send herewith one of the pieces of cloth for your inspection. Should the directors send the lake for trial to Dr. Bancroft, it is needless to inform that gentleman, that, in order to render it soluble in water, it is necessary to add to it a little pearl ash; but in case of their giving it to a practical artist, it may be proper to apprize him of this circumstance, as also that, in other respects, the process is nearly the same with that used in dyeing with cochineal.

"As the colours dyed, even with stick lac, though not quite so beautiful, approach very nearly to those of cochineal; and as there is a great consumption of it, particularly for dyeing red morocco leather, for which purpose it is exported in great quantities to Portugal and Barbary, I think there is every reason to believe that this lake may prove a valuable discovery."

A copy of the preceding communication, with a sample of Mr. Stephens's preparation, were transmitted by the board of trade to the honourable Court of Directors, with a recommendation (contained in their letter of the 7th of July, 1796,) that the sample in question should "be referred to Dr. Bancroft for examination and his opinion thereof," which (they add) "we request may be communicated to us." And in conformity with this recommendation, the committee of warehouses of the India Company, sent me, on the 8th of February, 1797, the samples of Mr. Stephens's preparation, with copies of the papers relating to it, and a request that I would inform them of the results of any experiments I might think proper to make therewith; and in particular "how far it might be adviseable to import any quantity, and to what extent such importation might be carried, and what might be its relative value, compared with cochineal."

According to my best recollection, the preparation made by Mr. Stephens was in the form of a *powder;* and though it was not without some defects, my opinion and report of it were, I believe, generally favourable; but I cannot find any copy of the report itself, which probably has shared the fate of the papers respecting East Indian cochineal, mentioned at p. 330 of the preceding volume.

Such was the origin of a species of manufacture or preparation, which (with a change of its form, to that of *cakes*, like those of indigo) has been lately carried to a very considerable extent in the East Indies, and thence brought to this country, in large quantities, under the name of *lac lake*. Indeed the sales of it, at the India House, within the last three years, have been so great, that in point of colouring matter, the quantity sold would have nearly equalled half a million of pounds weight of cochineal; but as it was prepared by different persons, with some variations in the quality, and as in all of it, the colouring matter was encumbered and deteriorated by other matters, partly extracted therewith, and partly added, to cause a precipitation of the colouring matter, so much difficulty and uncertainty attended the employment of the lac lake, that after having been sold to profit for some time, it ceased to find purchasers, even at a fourth part of the price which it would have brought, if the colouring matter had not been so deteriorated; and the scarlet dyers in the year 1810 were generally determined to abstain from the use of it. Unwilling that a matter which seemed capable of being rendered highly beneficial to the public, as well as to individuals, should be lost, I was induced to enter upon a series of experiments, not only with the lac lake, but also with the lac colouring matter in its natural state, for the double purpose of removing or correcting those defects which had

obstructed the use of the *former*, and of discovering better methods and means of extracting and concentrating the *latter*, than any which then appeared to have been employed for that purpose in the East Indies.

That I may abridge the account, and avoid the details of a part of my experiments, I beg leave to refer those who desire more information concerning the constituent parts of *stick* lac, to Mr. Hatchett's "Analytical Experiments and Observations on Lac," printed in the Philosophical Transactions for 1804, which, (though I am not prepared to adopt some of his inferences,) will afford the best information yet published on that subject, and shall content myself with observing, that besides the colouring and other *animal* matters, composing or proceeding from the insects and their eggs,* *stick* lac, separated from the wood, consists of a *resin* very much resembling that produced by the hymenœa courbaril (commonly called gum anime) and that denominated copal, together with a small portion of a species of wax, possessing most of the properties of myrtle wax, obtained from the berries of the myrica cerifera. In the greater part of the stick lac which I have tried, this resin has appeared to amount to about two-thirds of the whole, but it is always in a lesser proportion when the colouring and other animal matters are most abundant; and these are liable to such variations, that some pieces of very dark stick lac have, in my experiments, afforded as much colouring matter as a sixth part of their weight of fine cochineal, whilst other pieces of a light amber colour would only yield as much as a fifteenth part. Judging, however, from the samples which I have tried,

* Mr. Hatchett seems to have confounded all these *animal* matters (including even the insects) under the denomination of *Gluten*, and excepting only what he calls "colouring extract."

I conclude, that stick lac, as commonly imported, contains nearly as much colouring matter as one-tenth of its weight of cochineal.

It seems probable, that if the lac insects in their different states, and their eggs, could be divested of, or separated from, the resin composing their cells, and distinctly collected, without any extraneous or useless matter, they would afford as much colour, and prove as valuable, as an equal weight of cochineal. But their utility and value to mankind are greatly diminished by the strong and very hard covering by which they are naturally surrounded and protected, instead of the farinaceous and filamentous clothing of the cochineal. It is, indeed, true, that the resin composing the cells of the lac insects, may be dissolved by alcohol, and by the several alkalies; but the former solvent would prove too costly, and both it and the alkalies would, at the same time, dissolve the colouring matter, and render it, in a great degree, useless to the dyer, by confounding and uniting it with the dissolved resin; and it has, therefore, been deemed expedient to break the cells of stick lac mechanically, by pounding or grinding; but when this has been performed, it is found that water, which is the most proper *menstruum* for *adjective* colouring matters, (and the only one capable of dissolving that of the lac insect, without, at the same time, dissolving something hurtful or inconvenient to the dyer) will, according to my experiments, extract but a very limited portion of *that* which is under consideration; for having several times mixed water in a close vessel with a very great *superfluity* of the *richest* stick lac in powder, and kept them during twenty-four hours in a sand bath, at the heat of nearly 200 degrees of Fahrenheit and afterwards decanted the clean liquor, I could never find that the latter, however small its proportion might be to the lac, had re-

tained in solution more colouring matter than was equivalent to two grains of cochineal for each ounce of water, unless the latter had been partly evaporated after being saturated with colouring matter. It was, probably, this difficulty of extracting the colouring matter from stick lac, without a very great proportion of water, (even when boiling) that induced the manufacturers of lac lake to increase its solvent power, by adding alkalies to it, particularly soda, an addition which was not proposed by Dr. Roxburgh, nor, as I believe, practised in the earliest preparations of that drug: but it has, unfortunately, enabled the water, besides the colouring matter, to extract and unite with the latter so much of the resin* as is sufficient, when afterwards precipitated by alum, to render the lac lake completely insoluble by water, and nearly so by the acids commonly employed in dyeing scarlet. It may, indeed, be dissolved by *all* the alkalies, but when so dissolved, the colour will not attach itself to the cloth, unless the acids in the dyeing liquor are sufficient in quantity to *predominate* over the alkalies; and when this is the case, the resinous lac lake will immediately curdle, and form little masses, which, by retaining a great portion of the colouring matter, render it useless. These resinous masses, also, being in some degree liquefied by the boiling heat of the dyeing liquor, have frequently attached themselves in small *patches* to the cloth, so firmly, that nothing could afterwards remove them, without injuring either the cloth or the

* Mr. Woodcock, who, beneficially for the East India Company, (as I believe) performs the duties of Inspector of the Cloths dyed for their account, has informed me that, according to his experiments, the greater part of the lac lake, as commonly prepared, contains about one-third of its weight of resinous matter; and this is nearly the result of my experiments.

scarlet colour which it had received. It seemed, therefore, highly important to discover better means or methods of extracting and collecting the colouring matter of lac, so that it might be presented to the dyer in a form which would render its use as simple and convenient as that of cochineal: and I therefore made a great number of experiments, not only to attain this object, but moreover to ascertain, whether, in all the strictness of truth, the colour of the lac insect, when employed to dye scarlet, could be made to equal that of cochineal in lustre and vivacity, as a persuasion to the contrary had long been prevalent, and supported by very respectable authorities, particularly those of Hellot and Berthollet, of whom the former, in admitting that the scarlet dyed from lac is *more durable* than that of cochineal, represents it as not possessing equal vivacity, (" *éclat*"). See Art de la Teinture, &c. chap. xv.) Berthollet also says, " La couleur qu'on obtient de la laque n'à pas l'éclat d'une écarlate faite avec la cochenille, mais elle à l'avantage d'avoir plus de solidité." (Elements, &c. tom. ii. p. 204.)

In opposition to these and other authorities, I soon convinced myself, that the colour of the lac insect was capable of producing effects similar to those of cochineal, with the various preparations and combinations of tin, (so amply described in the preceeding chapter,) and that, even with the common dyer's spirit, or nitro-muriate of that metal, and tartar, it might be made, at least on a small scale, to dye scarlets, equal in vivacity and beauty to any which have been produced from cochineal, and by the same means, taking care only to employ them *in a proportion somewhat larger*. The ascertaining of this fact, I considered as a matter of some importance, for if the colour, as it exists naturally in the stick lac, had been incapable of producing a scarlet sufficiently bright

and lively, I could not have hoped that it would be improved in that respect by being separated and collected in the form either of an *extract* or a *precipitate*.*

* The lac lake appears to partake more of the nature of a *precipitate* than of an *extract;* the colouring matter, after it has been dissolved and separated by boiling, or hot water, with the assistance of soda, being precipitated by alum; which, moreover, by its sulphuric acid, neutralizes the soda, and throws down the *resin*, (dissolved by the latter) in combination with the colouring matter. The precipitate so obtained, besides other matters, which at best are useless, contains two, which are hurtful; for, in addition to the resin, (the ill effects of which have been already noticed) it retains a considerable proportion of alumine, which, when employed as a basis for the lac colour, produces on woollen cloth only a dull red, greatly inferior even to that commonly dyed from madder with alum. It is, indeed, true, (as I had discovered twenty-five years ago, and noticed at p. 232 of my first publication on this subject) that the oxides of tin, by their superior attraction for the lac colour, (as well as for that of cochineal) will decompose and separate the latter from any combination with alumine, (and even with iron,) so as to obviate that degradation of colour, which either of these would otherwise produce. But to obtain this effect, the oxide of tin must be employed so *copiously* as to *saturate completely the affinities* of the colouring matter, which will only relinquish its attachment to the alumine, (or the iron,) in proportion as it is adequately supplied with a *more attracting* basis, and, therefore, though the ill effect of an aluminous *precipitant* for the lac colour may be overcome, it is desirable that it should not be employed without necessity.

It is said, by well-informed persons, that the manufacturers of lac lake moreover employ a small portion of powdered bark of a shrub, there called *atour* bark, which they mix with the solution of alum, intended to precipitate the lac colour. It will be recollected, that Dr. Roxburgh, (as was mentioned at p. 10 of this volume,) after describing the process recommended by Hellot for effecting a precipitation of the colouring matter of lac by alum, and a decoction of comfrey root, proposes, as a substitute for the latter, to employ a mucilaginous decoction of the seeds of the *cassia tora*, Linn., and I suspect this to be the shrub from which the bark called atour bark is taken; but whether this suspicion be well founded or not, I confess myself unable to conceive any benefit likely to result from this

In the course of my experiments I discovered, that water, when at the common temperature of the atmosphere between the tropics, would dissolve and extract almost as much of the colour of powdered stick lac, as when assisted by a boiling heat; a fact never suspected, as I believe, by any other person, and of considerable importance to those who may engage in the business of separating the colour from stick lac, as it will enable them to avoid the expense of fuel, to which the preparers of lac lake appear to have hitherto subjected themselves.* I discovered, also, that water of this (com-

addition. Hellot found, that though alum would precipitate the colour when suspended in water; yet, when he endeavoured to collect the precipitate by filtering, the water which passed the filter carried with it more colour than he was willing to lose, and he imagined, that a mucilage of the comfrey root helped to obviate this waste, by obstructing the pores of the filter. But in preparing the lac lake no such purpose is to be answered, the soda which is employed, and resinous part of the lac curdled by the alum, forming so complete a precipitation, that the clear supernatant liquor may be sufficiently drawn off, without any separation by the filter.—Possibly the atour bark may contain *tannin*, and as the lac insects afford a small portion of animal jelly, (gelatine,) though less than cochineal, this tanning principle might coagulate the gelatine, and thus help to precipitate with it the colouring matter, if any such help were wanted, which to me does not seem probable.

* Stick lac ought never to be subjected to the action of *boiling* water when the colouring matter is intended to be extracted; for at the heat of 212° of Fahrenheit, the resinous matter composing its cells, will be so far liquefied, that their partitions, if unbroken, will cohere, and by inclosing the insects and their eggs, will render their colouring matter inaccessible to the action of water; and even when the cells have been destroyed, as in finely powdered lac, the fragments of the insects, with their eggs and colour, will be so far confounded and involved with the liquefied lac, as to be thereby *protected*, and rendered insoluble by any thing which does not previously dissolve the resin, and, by so doing, render the colour unfit for the dyer's use. But this liquefaction will not take place whilst the heat is less than 190 degrees of Fahrenheit, which it

mon) temperature, extracted the colouring matter *unincumbered* by a portion of other useless animal matters, dissolved by it when boiling; and having carefully evaporated a few quarts of this cold infusion of powdered stick lac, made during some warm days in the early part of September, I obtained an extract, which, when dried and rubbed in a mortar, broke readily into fine powder, and was afterwards found to dissolve almost as speedily as refined sugar; and having tried this powder to dye small pieces of broad-cloth, with the usual mordants, I had no difficulty in producing therewith scarlet colours equal to the best which could be any where found, and with little more than half as much in weight of the powder as would have been required of cochineal to produce similar colours. This powder, which at the actual price of cochineal, would have been worth nearly three guineas the pound, seemed to consist, almost exclusively, of pure colouring matter, and to be capable of answering every purpose which could be desired, or at most to be only objectionable from the circumstance of its requiring an evaporation of the water, instead of being more expeditiously separated from it by precipitation. But I thought it desirable to collect and produce this matter, in a state which would admit of its being readily dissolved by water; and this could never be the state of a precipitate from water; for the means which must have caused the colouring matter to separate itself from its aqueous menstruum and *subside*, even while *moist*, would necessarily render it insoluble by a similar menstruum, after being dried. I was moreover convinced, by the extraordinary effects which I had witnessed from a species of machinery which I formerly erected at Brentford,

ought, therefore, always to be, when we wish to obtain the colouring matter of stick lac.

for the purpose of evaporation, and by which a prodigious multiplication of surfaces, with a rapid motion of the air, were produced,* that no very considerable dif-

* A principal, and I believe *novel*, part of this machinery, consisted of a wheel resembling, in most particulars, that of an undershot water-mill; but instead of *float boards*, its whole circumference was covered or surrounded by a strong, coarse, porous horse-hair cloth, three feet in width; within this were placed two other circles or circumgyrations of the same hair-cloth, at the distance of twelve inches from each other. The axle of the wheel was placed so that the outer circumgyration of cloth, three feet in width, at every turn of the wheel, was, through its whole surface, immersed several inches in the fluid to be evaporated, which was contained in a very large shallow leaden pan, fixed upon cast iron plates, and heated by a fire below; and this cloth, in making the rest of its circuit, after passing through and taking up the hot liquor, constantly let a considerable part of it fall in drops upon the inner circles of cloth, from which it ultimately descended into the pan. The wheel also, at its opposite and most distant extremities, threw off some of the fluid through which it had passed, and this was received by walls constructed for that purpose, and heated by *flues* from the *fire under the pan.* These walls were covered by sheet lead, which was made to carry back into the pan the fluid thrown upon it.—But this not being sufficient, a small pump, worked by the same power which turned the wheel, was made to raise, and by the help of pipes, with suitable perforations, to distribute *more* of the fluid over the whole surface of these leaden coverings, from which it constantly trickled down into the pan. By these means the surface of the fluid to be evaporated was vastly multiplied, and the motion of the wheel, with the warmth between its partial inclosure, occasioned a constant application of dry or fresh air to the dispersed fluid; and this, if it had been required, might have been at any time greatly increased by applying the *centrifugal* bellows, described by the late Mr. Desaguliers, in the 39th vol. of the Phil. Transactions. When the fluid in the pan began to acquire consistency, and *approach* to the condition of a moist or soft extract, it was removed, and the evaporation completed by an apparatus, which I need not describe, because its purpose might be speedily and beneficially effected in the East Indies, by a simple exposure to the sun and dry air, with proper *stirring* to break or obviate the formation of a crust or pellicle on

ficulty or expense would attend this mode of preparation, especially when assisted by the very *hot* and *dry* atmosphere which prevails in the East Indies during a great part of the year; and considering the abundance as well as the low price of stick lac in the East Indies, I was convinced, that this mode of extracting and importing the colour of the lac insect, might supersede the use of cochineal in Great Britain, and afford the means (so much wanted) of remitting several hundred thousand pounds annually from India, with the additional advantage of substituting a *cheaper* production of *British* India for one derived almost exclusively from *Spanish* America.

Under this conviction, I (in October, 1811) addressed a Letter to the Chairman of the Court of Directors of the East India Company, offering to communicate what I considered as important on this subject; but, at the same time, intimating, that as I had been in a great degree frustrated of the fair advantages of another discovery, (to be mentioned hereafter,) I could not, on this occasion, exercise that liberality to which I had been inclined and accustomed in regard to my discoveries, and must hope for a reasonable, though moderate, remuneration for the advantages to be derived from the proposed communication. This letter, accompanied by samples of *very fine scarlet* colours, which I had dyed from the preparation before-mentioned, having been re-

the surface, which last should be as much *extended* as it can be without inconvenience. The fire might also be spared in that climate, and a wooden vat substituted for the *pan*, unless the fire should be found necessary to hinder the commencement or progress of a putrefactive process, to which the *animal part* only of the stick lac is liable. Fortunately, however, the colouring matter of this insect, like that of the cochineal, is not injured by a small degree of putrefaction.

ferred to the Committee of Directors for *buying*, (to which all matters connected with dyeing are submitted) I was requested, by that Committee, (previously to a final determination on the proposition contained in my letter,) to dye a piece of *long-ell*, (the woollen cloth of which the Company's exports are chiefly composed,) from *stick* lac, to be supplied, together with the cloth, by the Committee, in order, as was afterwards explained, to establish the practicability of producing good scarlets from the colour of the lac insects upon *whole* pieces of cloth; the samples which I had sent having been taken from *small* bits of cloth. In compliance with this request, I, on the 25th of January following, dyed *six* pieces of the Company's long-ell cloth, at the dye-house of Messrs. Barchard and Co. at Wandsworth, (by whom a very considerable part of the Company's scarlet cloths are dyed,) solely from stick lac, which had been sent to them by order of the Committee; and I found no difficulty in producing from it, with only the common mordants, (furnished by Messrs. Barchards,) a scarlet colour, in every respect equal to that dyed upon similar cloths from cochineal, by the same mordants. This operation was performed in the presence of very competent judges, who unreservedly approved of the colour, as the Committee did afterwards, when the cloths were returned to them by Messrs. Barchards, with an affidavit from me, stating that, according to my best knowledge and belief, no colouring matter had been employed in that operation, excepting that of the stick lac furnished by the Committee, to which, indeed, I had had no access, but in the presence of witnesses.

The practicability of substituting the colour of the lac insect for that of cochineal, and of producing therewith scarlets equally beautiful, (and more durable,) being thus *established*, I was requested by the committee

to prosecute the subject, by preparing a sufficient quantity of the extract, which I had proposed as a substitute for cochineal, and dyeing with it a piece of the long-ell cloth;—and, accordingly, I soon after (by infusion) impregnated about twelve gallons of water with as much of the colouring matter of stick lac as I could conveniently make it dissolve, and requested those respectable chemists and druggists, Messrs. Corbyn and Co. to allow it to be evaporated in their elaboratory, and under the care of their operator; to which they readily and obligingly consented; unfortunately, however, it appeared, after the evaporation was finished, that the fire had not been sufficiently moderated in the concluding part of the operation, and that a portion of the extract was in some degree charred, or carbonized, and thereby rendered insoluble; and that the other part had suffered injury from the heat, though in a less degree. I determined, therefore, not to employ this preparation; but make another, substituting only a *vapour* bath for the *naked* fire, by which the first had been evaporated, and in this last there was, I believe, no combustion, as I found it readily soluble by water; but Mr. Corbyn, (who, knowing the purpose for which the extract was intended, had paid particular attention to it,) informed me, that he had noticed a sudden and remarkable diminution of the beautiful colour of the liquor, when it began to acquire a little of the consistency of a soft extract; and I found afterwards, that the colour which it produced by dyeing, was deficient in brightness or vivacity, but not to such a degree as to deter me from making a trial of it, though I previously intimated to the committee, (by letter, addressed to Mr. Davison,) my apprehension of a want of success; an apprehension which was verified by an experiment made on a single piece of the long-ell cloth, at the dye-house of Mr. Ste-

venson, in Brick-lane, Old-street, on the 16th of March, when the colour produced was so far deficient, that I requested Mr. Woodcock to consider and report the experiment as one which had failed.

Twenty years ago, Fourcroy had noticed and mentioned, (in the 5th vol. of the Ann. de Chimie,) the strong disposition of the aqueous extracts of several colouring matters to attract from the atmosphere, and combine with large proportions of oxygene, and thereby acquire new properties; and I had witnessed this effect in making the extracts of different vegetable colouring matters, particularly that of logwood, even when the heat employed was less than that of boiling water, at which, or rather beyond it, most organized bodies, whether animal or vegetable, are liable to decomposition: I, therefore, concluded, that even the last extract, made at the elaboratory of Messrs. Corbyn and Co., must have been injured in the former or latter of these ways, though that which I had before prepared on a smaller scale, and which therefore was subjected to the action of heat for a shorter time, had received no injury; and it being impossible in this climate, and at that season of the year, (which had been uncommonly wet,) to produce an extract by evaporation, with *only* the heat of the sun, and the aid of a dry atmosphere, as might be done in the East Indies, and, consequently, impossible by any experiment *here* to ascertain how far the preparation in question might be advantageously made in the country where *alone* I had proposed that it should be made, I resolved to leave that question to be decided by *future* experiments in the East Indies, and in the mean time to endeavour to ascertain how far it might prove advantageous to *collect* the colouring matter of lac, by *precipitating* it, from its aqueous solution, *not by alum*, according to the present practice, but by the

oxide of tin, which would afterwards afford the only proper basis of a scarlet colour, instead of the improper one to which it has been hitherto united by the manufacturers of lac lake. I had previously found, by repeated experiments, that tin dissolved either by the muriatic or nitro-muriatic acids, would occasion a very copious precipitation of the lac colour, and that, after letting off the clear superincumbent water, the precipitate might be completely separated from all the remaining moisture, by suspending it in close linen bags, as is done with indigo, and afterwards drying it in the sun, and even in the shade. The muriate of tin has seemed to act rather more efficaciously than the nitro-muriate as a precipitate, and it possesses the advantage of being also the cheapest. One pound of muriate of tin, in which the acid of the ordinary strength (1170) was *saturated* with the metal, and which in London would cost about one shilling, appeared capable of precipitating as much of the colouring matter of the lac insect, as, *in its effects*, would be equivalent to one pound of cochineal; and though this might a little exceed the cost of the alum required to produce an equal precipitation, it would ultimately prove cheaper, because the oxide of tin would be all preserved, and being dissolved by the proper acids, would serve, in dyeing scarlets, as a basis to the colouring matter, without the help of any other, or more of the solution of tin.* Convinced of these

* There would be no difficulty in preparing the nitro-muriate of tin, at least in the East Indies—that metal, of the purest quality, being found at Banca, Malacca, &c., and salt-petre being there much more abundant and cheaper than in Europe. This last may be advantageously decomposed by argillaceous and ferruginous earths, and its acid thus obtained by distillation, without any intermixture of sulphuric acid; a circumstance of no small importance, for the reasons mentioned in the preceding chapter,—and the ni-

facts, I, about the end of May last, precipitated by the muriate of tin as much of the lac colour as, according to my estimate, would be more than sufficient to dye a piece of the long-ell cloth. But in trying it, I wished also to make an experiment with the lac colour in a more *simple* state, that a comparative estimate might be formed of their respective advantages. I had some months before sent a few pounds of the stick lac, (separated from the wood), to Mr. J. Bell, druggist, in Oxford-street, to be pounded; and wanting some of it *immediately* for an experiment, I requested that he would cause a part only of it to be powdered, and sent back as soon as possible, keeping the remainder to be done at his own convenience. Accordingly, I soon received back from him about one-third of the quantity which had been sent, and was agreeably surprised to find that it afforded much more colouring matter than I had expected; but having occasion afterwards to employ the remaining two third parts, I, with equal surprise, found it to be almost destitute of colouring matter; which led me to suspect that some mistake or improper mixture had been made. Mr. Bell, however, accounted for the difference between the first and second parcels, by assuring me, that the man employed to powder the lac had at first subjected the *whole* of it to the action of the pestle for a short time, and had then separated the finer part for my immediate use, by sifting it. This information having excited my particular attention, I made several experiments, which confirmed Mr. Bell's explanation, and proved, that the darker and richer pieces or parts of the stick lac, being always most replete with the cells, bodies, and eggs of the in-

tric acid being obtained, it would only be necessary to add sea-salt to produce the nitro-muriatic.

sects, were constantly broken by the pestle, sooner, and with much greater facility, than the more solid amber-coloured pieces, containing but few cells or insects, with but little colouring matter; and that by sifting the lac from time to time, whilst under the operation of pounding or grinding, a portion of it, equal in weight to about one-fourth part, when the lac is of good quality, might be separated, which portion would contain at least three-fourths of the colouring matter of the *whole* original quantity; and that the remaining fourth part might be dissolved or extracted by water, of the common temperature of the atmosphere,* in the East Indies, and superadded to the powder, containing the other three parts, by spreading the latter in a situation where it would be fully exposed to the sun's rays, and sprinkling or impregnating it, from time to time, with the water containing the dissolved colour, until the whole shall have been thus superadded and evaporated, as would there be in a very short time.

By this process three pounds of the powder (resulting from it) might easily be made to contain and yield the colouring matter in its *best* state, of ten or twelve pounds of lac, separated from the sticks; and it was this preparation which I proposed to try, in order to compare its effects with those of the lac colour precipitated by the oxide of tin. Accordingly, I separated by sifting, from eleven pounds of ordinary stick lac in powder, about three pounds and one quarter of the finer part, which, by an experiment upon a small scale, appeared to contain nearly as much colour as one-third of its weight of cochineal. I did not, on this occasion, think it necessary to take the trouble, or incur the delay, of extracting the colour of the remaining seven pounds

* After this extraction of the colour the residuum would be seed-lac, of a very good quality.

and three quarters, and of superadding it to the former, as just described, by evaporation, (for which this climate is but little suited,) having previously and satisfactorily performed this part of the experiment upon a smaller parcel.

With each of these preparations, an experiment was made at the dye-house of Mr. Stevenson, on the 15th of June, 1812, in the presence of Mr. Woodcock, who attended in behalf of the Committee; but neither of them fulfilled my expectation in regard to the *quantity* of colouring matter afforded by it. The piece of long ell-cloth dyed from the *sifted* lac, took, indeed, a scarlet colour, which was liable to no objection, but that of its wanting a little more body or fulness, to make it appear to the utmost advantage; and this defect I then supposed, and have since ascertained by repeated experiments, to have resulted from the shortness of time and insufficient quantity of water employed to dissolve and extract the colouring matter. In my own smaller experiments, I had put the sifted lac to soak or macerate during the preceding night, with a copious allowance of water; but this precaution was wholly omitted in the experiment under consideration, because I wished that nothing might be done in the absence of Mr. Woodcock; and in consequence of this omission, the colouring matter of the sifted lac was not extracted so as to produce its full effect; otherwise being, as in the former experiment at Wandsworth, in its *natural* and *best* state, its effects must have been, as on that occasion, *perfectly* satisfactory.

In regard to the piece of cloth for which the lac colour, precipitated by muriate of tin, had been employed, there was, I believe, no reason to conclude that a scarlet sufficiently bright would not have been produced, if an adequate portion of colouring matter had been applied to the fibres of the wool; and several causes presented them-

selves to my mind as capable of having produced this deficiency,—of these, the most obvious was that of a considerable part of the precipitate being left at the bottom of the dyeing vessel *undissolved.** This I mentioned to to Mr. Stevenson (as well as to Mr. Woodcock) at the time, and proposed to draw off the upper part of the water, so as to examine the sediment; but I was told, that the particular vessel in which this experiment had been made could only be emptied by lading the water upwards, which would necessarily cause too much agitation for my purpose. There was another cause, which seemed probable, from recollecting the fact mentioned in the preceding chapter, of the action of tin, when much oxygenated, upon the colouring matter of cochineal, which, in regard to its effects, is thereby in a considerable degree diminished, or made latent. I then thought it likely that, in drying the lac precipitate, by the heat of a fire, the oxide resulting from the muriate of tin had (as it is always strongly disposed to do) acquired such an addition of oxygene from the atmosphere, as to occasion the disappearance of a part of the colour. To ascertain the truth on this point, I macerated a portion of stick lac in powder, with a suitable quantity of water, and having afterwards strained off the clear infusion, I divided it by *measure* into two equal parts, from one of which I dyed, with the usual means, a certain quantity of broad-cloth, adding more of the latter,

* The precipitate in question being like *all* others, necessarily insoluble by water alone, I had, in my own experiments upon the small scale, commonly rubbed it in a glass mortar with a little diluted muriatic acid and tartar, and left them afterwards to macerate during the following night; but this precaution, like that in regard to the *sifted* lac, (recently mentioned,) was omitted, and for the same reason, joined to the expectation which I then entertained, that the acids in dyeing liquor would suffice to dissolve the precipitate, during the operation.

until I had completely *exhausted* the colour; and having precipitated the colouring matter of the other half, by the muriate of tin, and dried the precipitate (in the same way as I had done that employed on the 15th June) I afterwards dissolved the precipitate so dried, by diluted muriatic acid and tartar, with which, (and without any other mordant,) I dyed an equal quantity, by weight, of the same broad-cloth, and found the scarlet thus produced was in every respect equal to that which had been previously dyed by the lac colour in its best state; and, consequently, that this mode of precipitating the colour had not caused the deficiency in question. In addition to these, there was a *third* cause, which might be suspected of having operated in producing this deficiency, which was the insufficiency of the water employed to dissolve and extract the colouring matter of the lac.—I had not, in making the precipitate, properly attended to this circumstance; but when I came afterwards to reflect and calculate, I found that the quantity, as far as I was able to ascertain it, must have been too small to dissolve so much of the colouring matter as I had supposed to have been extracted and precipitated for the experiment in question; and I found also, that this must have happened in regard to the extract prepared by the operator of Messrs. Corbyn and Co. for the experiment of the 16th of March, for which twelve gallons only of the aqueous solution were sent to be evaporated; and my experiments having shown, that each gallon of water will only extract colouring matter equivalent to half an ounce and a few grains of cochineal; and ten ounces of the latter being required to dye a piece of the long ell-cloth, it must be inferred, that the quantity of lac colour employed for that experiment was much too small to produce the desired effect.

That the first and the last only of the three causes,

just mentioned, occasioned the deficiency of colour afforded by the *precipitate* employed on the 15th of June, has been since proved, by experiments made upon a small scale, with a sample of that precipitate, which had been preserved, and which being properly dissolved by a little diluted muriatic acid and tartar, and employed in the same proportion as it had been on the 16th of June, was found to produce much more effect, than that which was then produced, though it did not dye a *full* bright scarlet, until it was employed in a proportion, *greater by at least* fifty *per cent.* Similar results were produced by a part of this sample, which had been macerated with an equal weight of carbonate of soda in water, by which the colouring matter was nearly all dissolved and separated from the oxide of tin, and the clear solution being poured off, it produced, in a similar proportion, a very good scarlet, with the nitro-muriate of tin and tartar, employed a little more freely, indeed, than is usual, in order to neutralize the soda.

In regard to the extract prepared by the operator of Messrs. Corbyn and Co. which was tried on the 16th of March, I beg leave to add, that I did then suppose that it must have suffered some injury during the evaporation, by an absorption of oxygene in the concluding part of the operation, as frequently happens to vegetable extracts; and wishing to ascertain the truth on this point, I, on the last day of the year 1812, took a very small sample, which had been reserved, of that extract, and put it into a glass with hot water, and twice its weight of sugar, (which I had found to be very efficacious in the *de*oxygenation of indigo,) and having rubbed these until both were dissolved, I left them together during twenty-four hours, and then employed them in dyeing a bit of broad-cloth with nitro-muriate of tin and tartar, and had the satisfaction of thus producing a very

fine scarlet, equal to almost any which can be obtained from cochineal. This experiment seemed to prove, at least, that the lac colour had suffered no *irreparable* injury by being evaporated, and brought to the form of a dry extract; but it did not prove that the colour, though much better than I had formerly produced with the same extract, had been improved by the *deoxygenating*, or any other influence of the *sugar;* and being anxious that no uncertainty should subsist in regard to this fact, I, on the 4th of January, 1813, applied to Mr. Woodcock at the India House, and obtained a small part of a sample of this extract, which had been reserved for the Committee, and with this I made another experiment, similar to the former, excepting the sugar, which was omitted, and I found, unexpectedly, that the scarlet then produced, was so nearly equal to the former, that I could no longer ascribe any considerable benefit to the sugar. I found, indeed, that the colour did not acquire its utmost brightness until I had employed a greater proportion of nitro-muriate of tin and tartar than is commonly employed with cochineal, and a greater even than that which has appeared to be necessary with the lac colour in its natural state.—Whether this seeming necessity for an increased proportion of these mordants was created by any change which the colouring matter had undergone, by being brought into the state of an extract, I am unable to determine; but I think it probable, that if the same mordants had been *more freely* employed in the experiment of the 16th of March, better effects would have resulted, though, from the deficient *quantity* of colouring matter, a good scarlet could not, I think, have been obtained.

Soon after I had written to the Chairman of the Court of Directors, as before mentioned, a *new* preparation of lac colour, under the name of *lac dye*, was imported by

the East India Company, (prepared under the direction of Mr. Turnbull, a surgeon in their service,) which, though not exempt from the inconveniences of the lac lake, retained them in a smaller degree, and with the advantage of yielding a greater proportion of colour. This preparation was, however, left unemployed until after my experiment at Wandsworth had *established* the practicability of substituting the colour of the lac insect for that of cochineal.—But within a fortnight after this had been done, the Committee of Buying determined to distribute this lac dye, among the Company's dyers, at a moderate price, to be employed in dyeing their cloths; and also to allow a portion of the lac lake, to be employed for the same purpose *conjointly* with cochineal; it being found that the difficulties resulting from the insolubility of the former and latter, might be greatly diminished, by *a very minute mechanical division*, or grinding between stones, particularly adapted to that purpose. But in permitting this use of the lac dye and lac lake, the Committee properly required and obtained, from the dyers, a diminution in the price before paid for scarlet colours, which, in the course of three or four months, had, as I am informed, produced a saving to the Company of fourteen thousand pounds, without any inferiority in the scarlet so dyed, as far, at least, as I have been able to observe, or learn; and though, in a few instances, the cloths were injured by adhesions of the *resinous* part of these preparations, the injury was probably occasioned by their not having been so finely ground as they ought to have been.

This was the state of things when my last experiments were made on the 15th of June, and their imperfect success having occasioned some doubt in my own mind, whether the proposed extract by evaporation, or the precipitate by an oxide of tin, would operate more benefi-

cially, and prove cheaper than Mr. Turnbull's lac dye, which had been supplied at a very moderate price, and it being difficult to ascertain the truth on this point *in this climate*, or, indeed, without trials upon a much more extended scale, in the places where such preparations were intended to be made, I candidly intimated this doubt to the Committee, and determined to publish an account of my experiments and ideas on this subject, and leave their accuracy and utility to be decided by the only certain test, that of future adequate experience,—and in order to facilitate this decision, I will here subjoin a few additional observations.

Should it hereafter be found advantageous to concentrate the lac colour in the East Indies by *evaporation*, it will be very desirable to increase the solvent power of water, in order to diminish the quantity of moisture to be evaporated. The alkalies are unfit for this purpose, because, as I have already intimated, they occasion a solution of the resin, as well as of the colouring matter of the lac. The nitric acid cannot be employed in this way, because it exerts a *destructive* action, similar to combustion, upon the colour; but this is not the case with either the sulphuric or muriatic acids, which greatly increase the power of water to dissolve and extract the colouring matter, with at most but a very inconsiderable portion of the resin. The sulphuric acid would, however, be preferable in several respects to the muriatic for this purpose, if it were either produced in the East Indies, or capable of being transported thither without danger. One gallon of this acid, of the ordinary strength, diluted by one hundred gallons of water, would enable the latter, at the ordinary temperature of the atmosphere, to dissolve *ten* times as much colouring matter as it would otherwise do; and the clear solution being drawn off, and one-half as much in weight of lime, as of the acid em-

employed being added, the latter would combine with the lime, and subside to the bottom of the liquor, which would then remain clear, with all its *scarlet* colour suspended therein, and capable of being drawn off without any of the sulphate of lime. This liquor would, however, still retain a small proportion of sulphuric acid, and it is necessary that it should do so, until after this separation from the sediment, for otherwise the water could not suspend all the colouring matter, and a part of it would subside and be lost upon the sulphate of lime; but this separation having been made, the remnant of sulphuric acid should be neutralized by soda* previous to the evaporation, for otherwise it would attract moisture, and even when the colour had been brought to the state of a dry extract, it would be disposed to deliquate, an inconvenience that does not occur when the acid has been completely neutralized; and its being so neutralized, is moreover necessary, to obviate the ill effect which the sulphuric acid might produce, when the extract came to be employed for dyeing scarlet with the nitromuriate of tin. When an extract has been prepared in this manner, it will dissolve readily in water, and produce good scarlet colours, with the mordants commonly employed for that purpose.

If *precipitation* should be found preferable to evaporation for separating and concentrating the lac colour, the quantity or proportion of water employed to extract it, will be of little consequence, especially as the water need not be heated.—Among all the substances capable of precipitating the lac colour from its aqueous solution, (of which I find magnesia to be one,) alum and the solu-

* I have in this and other places, directed the use of soda, in preference to potash, for neutralizing the sulphuric acid, because I have found the sulphate of soda invariably to operate more favourably in producing a scarlet colour, than the sulphate of potash.

tions of tin seem to be the most useful. When alum is employed, about half as much carbonate of soda should be added, which will completely throw down all the colouring matter; after which, the colourless fluid may be drawn off, and the precipitate may be suspended in close linen bags to drain, as is practised with indigo, and afterwards dried in the same manner. Such a precipitate would contain no resinous matter, and though not soluble in water alone, a small proportion of soda would enable that menstruum to dissolve the colouring matter, with a *part only* of the alumine, and the solution so made would, as my experiments have repeatedly proved, dye a good scarlet by the ordinary means, there being no resinous matter to curdle and attach itself to the cloth, and but a small proportion of alumine, which the oxide of tin, by its stronger attraction for the colour, would render harmless. By this method of dissolving and extracting the colour by *water only*, though it be afterwards precipitated by alum, a preparation, richer in colour than lac lake, or even the lac dye, might be obtained, and it would moreover be nearly exempted from the inconveniences with which they have been attended.

It seems probable, however, that a precipitation of the colour, by either the muriate or nitro-muriate of tin, as described at p. 28, would prove both cheaper and better than the latter by alum.

But though I have thought it expedient to state these observations, respecting the means and ways of extracting and collecting the colouring matter of lac, it is my own decided opinion, that the least expensive, most easy, certain, and useful form in which this colour can be presented to the dyer, is that which I have recently described at p. 29 and 30. Three-fourths of the colouring matter of a given quantity of the lac, will thus be brought into a fourth part of its natural or former bulk, most expedi-

tiously, and with very little labour; and the remaining fourth may be superadded without any perceptible increase of that bulk, and with much *less alteration* than it must suffer by any other mode of preparation: for the drying or separation of the water containing this part of it, being to be performed merely by aspersion upon a dry powder, and an evaporation with only the ordinary heat of the atmosphere, no deterioration or change can take place, like that to which extracts are liable, in passing from a fluid to a solid state, by the application of artificial heat: and certainly the very small difference of freight, if there should be any, between this preparation and the extracts or precipitates hitherto made, or proposed to be made, cannot amount to one fourth part of the unavoidable expense of making such extracts or precipitates. It is even highly probable, that with a little pains and ingenuity, stones and machinery for grinding the lac, and sieves or bolting cloths of a degree of fineness suited almost exclusively to the passage of the fragments of the insects and their eggs, might be contrived, and employed, so as to diminish the bulk of this preparation, much more than I have stated as being practicable.

By importing the lac colour in this form, (of a dry powder,) the dyer, to obtain and employ it in the purest and most perfect state, would only find it necessary to soak or macerate the powder, in the ordinary temperature of the atmosphere, or in water a little warmed during winter; putting it for that purpose into bags, porous, and only porous enough, to admit the water to pass and repass freely without the powder. Several of these, partly filled, might be put, a day or two before the colour was intended to be used, into a large cistern, copiously supplied with water, and being there agitated, from time to time, the colouring matter would be gra-

dually dissolved and dispersed in the water, which might be drawn off, and put into the dyeing vessel when wanted, adding more water to replenish the cistern: and this process might be continued until the water was found to extract no more colour; after which, the bags might be emptied into a large tub or cistern, and the powder subjected to the action of water acidulated by sulphuric acid, as lately described at p. 37 of this volume, in order to extract a remnant of the colouring matter, similar to that contained in seed lac, and which appears to have been always neglected and lost by the dyers of India. I had observed twenty-five years ago, as was mentioned at p. 271 of my first publication on this subject, that cochineal contained a portion of colouring matter, which boiling water could not dissolve, but which was readily extracted by the alkalies; and I have since discovered the same sort of colouring matter in the lac insect, and in nearly the same proportion, of about one-eighth or tenth of the whole, according to my estimate. This, however, cannot, like that of cochineal, be extracted by alkalies, without also extracting a portion of the resin. But it may be quickly dissolved by the help of sulphuric acid, employed and afterwards neutralized, as recently proposed at page 38. Though it will not require any subsequent evaporation, as for the preparation there mentioned. When this part of the colour shall have been extracted, the residuum will be of some value to persons who may be disposed to melt and strain it, in order to obtain a substance similar to shell lac.

In addition to what I have already mentioned of the mordants best suited to the colour of the lac insect, I need only observe generally, that the several oxides and combinations of tin, produce effects with it nearly similar to those which have been so amply described in the

preceeding chapter, as being produced by them with cochineal; but with this difference, that lac bears the action of acids better than the latter, and that, in order to obtain the brightest and best colours from it, these mordants, or the acid solutions of tin, ought to be employed more copiously than with cochineal. Had this fact been sufficiently known and attended to, the want of vivacity or brightness in the former would not have been so long a subject of complaint.—The oxides of tin having little or no attraction for the fibres of linen or cotton, the latter are as incapable of imbibing a durable scarlet from the lac colour by their intervention, as they are known to be of obtaining it by them from cochineal.

In regard to the other basis, I have already mentioned that the colour produced with alum from the lac upon *wool* is much *darker* and *less beautiful*, though more lasting, than that obtained from cochineal, with the same basis; and this is true in regard to *linen* and *cotton*. The lac colour is indeed used by the dyers of India, to give a dull red colour to the *coarse calico* employed for tents and other common purposes, of which I have been favoured with a sample by Mr. Wilkins. And this appears capable of resisting for a considerable time the action of water, sun, and air, but not of soap, to which, probably, it is not often subjected.

The oxide of zinc, when pure, produces bright colours, approaching nearly to scarlet, with the lac. That of antimony produces with the lac a colour darker than that which it produces with cochineal. The other metallic and earthy bases, however, seem generally to produce, with the former, effects differing but little from those which, in the last chapter, I have mentioned as being produced by the latter, with this exception, however,

that the lac colour seems not to be so much darkened by the oxides of iron, or by ammonia, as that of cochineal; and it is probably from this difference, that the lac scarlet has been found less liable to become spotted or stained by mud, sweat, urine, &c. than the common scarlet.

In regard to the greater durability of the lac colours above those of cochineal, I have seen it manifested by a considerable number of trials, in which they have been exposed and contrasted with each other. Indeed, the colouring matter of lac has so much affinity with the fibres of wool, that with a small intermixture of sulphuric or muriatic acid, *without any basis*, it will dye upon cloth lasting colours, much less darker and less vivid indeed than those produced with the oxides of tin, &c.

I have mentioned, in a former part of this chapter, that a part of my experiments had been directed to the subject of *lac lake*, with the expectation of removing the obstacles which had obstructed its use by the dyers. Many of these experiments produced results of little value; some of them, however, were attended with considerable success; and it is my intention soon to publish a short account of the latter, with instructions respecting the use of the lac lake in dyeing scarlet, upon a separate sheet, for those to whom such instructions may prove interesting. I do not include them in my present work, because it is directed towards objects of *permanent* utility, and I am persuaded, that the facts stated in this chapter will very soon produce such improvements in the form and manner of preparing the lac colour, as must render such instructions useless.

Believing that I have now done all that can be well performed or expected in this climate, and at this distance from the places where the lac is produced, to dis-

cover the best methods of collecting and introducing this colour, as well as to promote the use of it, I shall here leave the subject, to be taken up and prosecuted by those in the East Indies, whose pursuits may enable them, by adequate and decisive experiments, to ascertain the comparative merits of the several methods here proposed.

CHAPTER VI.

Of Prussian Blue.

"Presque tous les arts doivent leur naissance au hazard; ils ne sont en general, "ni le fruit des recherches ni le resultat des combinaisons; mais tous ont un rapport "plus on moins marqué avec la Chimie; et elle peut en eclairer les principes, en "reformer les abus, simplifier les moyens et hater leur progres."

CHAPTAL, *Elemens de Chimie.*

THE first discovery of Prussian blue, or prussiate of iron, as related by Stahl, was, like many other interesting discoveries, purely the effect of accident. About the year 1710, *Diesbach*, a chemist at Berlin, wishing to precipitate the colouring matter of cochineal from a solution or decoction, in which it was combined with a portion of green vitriol, or sulphate of iron, borrowed for that purpose from his neighbour Dippel, an alkali, upon and from which the latter had several times distilled an animal oil, and which had thereby become impregnated with the animal colouring part of Prussian blue; consequently this alkali, when mixed with the decoction of cochineal, or rather with the iron contained therein, immediately and most unexpectedly produced a very beautiful blue colour. The experiment being repeated, and always with the same effect, Diesbach availed himself of the discovery; and this new colour was made known and sold under the name of Prussian blue; and the means of producing it were kept secret until the year 1724, when Dr. Woodward published an account of the process in the Philosophical Transactions.

The cheapest way of preparing this animal blue, is, by burning dried blood, horns, hoofs, tendons, and other animal substances, so as to reduce them to coal; which is afterwards to be calcined with three times its weight of potash in an iron vessel. After about twelve hours of

calcination, the mixture generally appears like a soft paste, and then it is thrown into tubs partly filled with water; which last, according to Berthollet, will in part be decomposed by this addition, and a portion of its hydrogene, combining with a part of the nitrogene, contained in the calcined animal matter, will form ammonia, whilst another part of the hydrogene, by uniting with the remaining part of the nitrogene and the animal carbon, will produce the Prussian *colourable* matter: the oxygene of the decomposed water forming carbonic acid. The *colourable* matter being thus produced, and dissolved in the undecomposed part of the water, is poured, or drawn off, and filtered; and afterwards mixed with a solution of three parts of alum and one of sulphate of iron, in a sufficient quantity of water; and thus mixed, the colourable matter combines with the oxide of iron, and becoming *blue*, subsides with it to the bottom of the vessel, but commonly appears *green*, from an excess of the oxide of iron.

Care should be taken, however, as Gay Lusac has observed, not to subject the animal carbonaceous matter to an excessive heat, and for too long a time, for by *over calcination* it will lose its nitrogene, or azote, which is an essential constituent part of the colourable matter.

The oxide of iron, as M. Berthollet observes, may combine in different proportions with the colouring part of Prussian blue. Where it is greatly in excess, the compound will be yellow; but when the oxide is only in a suitable proportion, the colour will be blue. All acids, and particularly the muriatic, are capable of dissolving the excess of iron, so as to bring the compound to the proper state and appearance of Prussian blue. But farther than this, acids have no power of decomposing or dissolving any part of it, unless assisted by

heat. The animal colouring part of Prussian blue, (separated from the oxide of iron,) is called the Prussian, or Prussic acid, though I think improperly, as it does not possess the properties of an acid. This M. Berthollet admits, but adds, that it acquires them by combining with a metallic oxide, and is then enabled to saturate alkaline properties, ("les propriétés alcalines.") But this may also be done by oils and resins, with which the *Prussian colourable matter* seems to have more similitude than to acids.

I have just observed, that nitrogene is indispensably necessary to constitute the Prussian colourable matter, and this fact, in addition to that of its never having been obtained for any of the uses to which it is applicable, except from animal substances, intitles me to consider it as of an *animal* nature, though some small portions of it have been discovered in water distilled from the leaves of laurel, and from peach blossoms, and the kernels of apricots. But these, or any other vegetables which may be capable of affording what is called Prussic acid, can only do it by that small portion of nitrogene or azote which they contain, and by which they are, in that respect, assimilated to animals.

Scheele, to whose sagacity and indefatigable exertions chemistry has infinite obligations, made the first great advance towards the full investigation and right understanding of this very abstruse subject; upon which Berthollet afterwards threw considerable light, particularly in a memoir printed in the 13th volume of the Annales de Chimie; and M. Proust has since contributed very much to extend our knowledge, and rectify our conceptions of this matter, in two other memoirs, published in the same collection, particularly the *last*, in the 60th volume, to which I refer those who desire *fuller* information on this subject; meaning to content myself

with stating, as concisely as possible, the more important facts connected with my present work.

Prussian blue, as commonly prepared and sold, contains a considerable proportion of alumine, and very often silex, sulphate of lime, potash, phosphate of iron, and oleaginous ammonia, which may all be considered as extraneous impurities,—when it contains none of these, nor of alumine, it will, if scratched, exhibit the shining metallic, or *coppery* appearance, which commonly attends indigo.

The best Prussian blue made for sale, if finely powdered, and subjected to the action of pure caustic potash in water, may be dissolved, excepting a residuum, which, freed from every thing soluble, by subsequent additions of water, will consist of *red* oxide of iron and alumine, without any remnant of *colourable* matter—and the solution so obtained, being made to crystallize by the proper means, will ultimately afford more than nine ounces of pure crystals of Prussiate of potash for each pound of Prussian blue so employed, leaving in the mother water, according to Proust, alumine, sulphate, and phosphate of potash, and ferruginous alkaline carbonate. The crystals so obtained will be of a lemon colour, for which, and for their susceptibility of crystallization, as well as for their property of reproducing Prussian blue, with the *red* oxide of iron, Proust says, they are indebted to a certain *invariable* portion of the *black* oxide of iron, which, in his opinion, forms one of their *essential constituent* parts.

When, instead of pure caustic potash, a lye of the common carbonate of that salt is employed with the Prussian blue, a considerable portion of its *red* oxide will be dissolved, in the same manner as in Stahl's tincture of iron, and though the solution is only of a pale yellow colour, it may be rendered blue by the addition

of any acid, however pure; an effect which has frequently misled persons, who either did not know, or sufficiently attend to the cause of this effect; for as in this case the *blue* colour is revived without any addition of iron, we may infer, that the preceding disappearance of this colour was not caused by any deficiency of that metal; and I can only account for it, by adverting to a *fact*, that seems applicable to this, as well as to several other coloured matters, which lose their respective colours, some by the presence and *predominance* of an alkali, and others of an acid. In this case, the *blue* Prussian colour cannot manifest itself when the colouring matter is combined with an alkali in excess, or even an alkaline earth, (as is seen by lime-water,) but it becomes manifest, whenever the alkali is neutralized by an *acid* with a small excess of the latter.

Soda, in its mild and caustic states, acts like potash upon Prussian blue—and this is nearly true of ammonia. Lime-water also, moderately warmed, dissolves the Prussian colouring matter, holding it in solution with very little more of iron than that portion of the black oxide, which Proust considers as an *essential constituent* of the Prussian colourable matter. This fact was first discovered by Fourcroy, and it renders the Prussiate of lime much fitter to ascertain, as a re-agent, the presence of *iron*, than the Prussiates of potash, soda, or ammonia.

Scheele first taught us how to obtain the *pure* simple Prussiate, (consisting of nitrogene, hydrogene, and carbon,) by liberating it in the *gaseous* form, from an oxide of mercury, (with which it has a greater affinity than with the oxide of iron); but when so obtained, it has none of that *black* oxide of iron, which is essentially necessary to enable it to co-operate in the production of a blue colour; and, therefore, if it be mixed, and allow-

ed to stand in a phial, with the *red* oxide of iron, for months, it will not, as I have witnessed, contract any union therewith, or cease to be as *colourless as water;* but if a little *green* sulphate of iron, containing the *black* oxide, be added to the mixture, a slight bluish cloudiness will soon appear, and this will gradually increase, and at last terminate in a precipitation of *perfect Prussian blue.* This *simple* Prussiate may be easily decomposed, even by the rays of the sun, (which resolve it into carbonic acid, ammonia, and carbonated hydrogenous gas); but when it is in union with that portion of the *black* oxide of iron, which enables it, with the *red* oxide, to form Prussian blue, this fragility, and ready susceptibility of decomposition ceases; and it then becomes, what some have called a *triple* Prussiate, which I beg leave to denominate a *colourable* Prussiate of iron, or the Prussian *colourable matter*, to distinguish it from the other conditions in which it may exist.

It is remarkable, that when the *simple* Prussiate has combined with that portion of the black oxide of iron, which is necessary to render it a *colourable* Prussiate, its affinity protects the oxide from all farther oxidation; so that if it be mixed with the *green* sulphate of iron, in order to make Prussian blue, though the oxide of the latter (which at first exists only in the state of a black oxide, retaining twenty-eight per cent. of oxygene) will gradually rise from the minimum to the maximum of oxidation, (*i. e.* will increase its portion of oxygene from twenty-eight to forty-eight per cent., and by this increase produce that vivid colour which distinguishes the Prussian blue,) yet the portion of black oxide, which Proust considers as an *elementary* constituent of this colourable Prussiate, will not, at the same time, receive any, even the slightest accession of oxygene, but will continue unchanged, in the condition of a *black* oxide,

united to the oxygene, only in the proportion of twenty-eight per cent.

That iron, at the minimum of oxidation, is incapable, whatever may be the proportion, of becoming, or producing, *a blue* with the *colourable* Prussiate, may be demonstrated by several experiments, described by Proust. But the easiest and most simple is that of dropping some of the crystallized Prussiate into a recent diluted boiling solution of the *green* sulphate of iron, where it will cause a *white* precipitation, which Proust calls the *white* Prussiate of iron, and which is of that colour, *only* because the oxide is at the minimum of oxidation; but as *this* (unlike the *elementary* portion of black oxide) retains a disposition to become hyper-oxidated, it will constantly absorb oxygene, and gradually pass from the white to the blue colour; an effect which is analogous to some that we have found to happen with indigo, and which occur also to an infusion of galls, when mixed with the green sulphate of iron. I have obtained a similar *white* precipitation, in the same way, by substituting the Prussiate of lime for the crystallized Prussiate of potash; and also by substituting the muriate of iron, recently prepared, for the *green* sulphate; the iron in both being equally at the minimum of oxidation. I have also gummed this white precipitate, and applied it in *spots* to muslin and cotton velvet, and found it (by absorbing oxygene) to change speedily to a full and most beautiful blue; and this has happened to calico which I had soaked in Prussiate of potash and dried, upon my applying to it, in spots, a diluted muriate of iron thickened with gum—no colour was visible at first, but the spots soon became blue, by absorbing oxygene. But when, to a piece of calico impregnated with Prussiate of iron, in the same way, I applied a diluted nitrate of iron,

(also in spots,) the production of *blue was instantaneous*, because the iron in the nitrate was already at the maximum of oxidation. I found afterwards, upon soaking the same calico in hydro-sulphuretted water, that the blue spots, by *de*oxygenation, were again made white, and afterwards rendered blue a second time, by immersing the calico in a diluted nitric acid, which restored the oxygene.*

Bouillon Lagrange says, (Manuel de Chimie, ii. 653,) that the Prussic acid will decompose the oxymuriatic, by absorbing the oxygene of the latter, and that it will become odorous; and that, in this state, it will precipitate iron of a *green* colour, which green, by the contact of the sun's rays, or by an addition of metallic iron, or of *sulphureous* acid, will be changed to blue; and as these are all *de*oxygenating agents, we must conclude, if the fact be correctly stated, that the *green* colour, in this case, results from an *excess* of oxygene, and that it is changed to blue by an abstraction of that excess.

The uncommon beauty and lustre of the Prussian blue, have occasioned many endeavours to apply and fix it equally and permanently as a dye. The late Mr. Macquer first proposed two methods of doing this; but neither proved successful. In one he soaked the stuffs in a solution of alum and sulphate of iron, and then in a diluted Prussiate of potash; and lastly, in water a little

* M. Berthollet has supposed that the *white* prussiate of iron differs from the *blue*, not because it is less oxygenated, but because the sulphuric acid in the *green* sulphate of iron adheres most strongly to its basis, and as a proof of this, he says, that by adding either the muriatic, sulphur*eous*, or phosphor*eous* acids, to the white prussiate, it becomes blue, though neither can be supposed to afford oxygene. But it must have been almost impossible to make such an addition, without admitting oxygene from the atmosphere.

soured by sulphuric acid, in order to dissolve and remove any superfluous oxide of iron. By doing this repeatedly, he produced a very beautiful blue colour; but it took unequally, and the texture of the silken and woollen stuffs was rendered very harsh.

In Mr. Macquer's second process the stuffs to be dyed were boiled in a solution of alum and tartar, and afterwards in water, containing Prussian blue, which had been finely powdered. In this, however, the colouring particles were only suspended, without being dissolved, and therefore, though they were applied to the fibres of the stuffs, it was without any chemical union, and so *sparingly* as only to produce very faint shades of colour.

The Abbé Menon recommended a different process for dyeing linens and cottons with the Prussian blue. They were first dyed black in the usual way, with a ferruginous basis; and then soaked a few minutes in a diluted Prussiate of potash; after which they were boiled in water with alum, and took thereby a deep blue. In this case the Prussian colouring matter, assisted, doubtless, by the acid of the alum, seemed to exert a strong attraction upon the oxide of iron contained in the black dye, and thereby to decompose and separate the vegetable colouring matter, (of galls, &c.) and in its stead to combine with the ferruginous basis; but the colour took unequally.

Some years since, M. Roland de la Platriere* published among the "Arts et Metiers" of the Royal Academy of Sciences at Paris, an account of another method practised at Rouen for dyeing with the Prussian blue,

* This gentleman, divested of the name of *La Platriere*, was one of the ministers of the French Republic, in the early part of the Revolution, and, perhaps, one whose conduct was the least exceptionable.

in many respects similar to Mr. Macquer's second process; but with this difference, that the Prussian blue in fine powder was suspended, not dissolved, by a diluted muriatic acid, instead of pure water; a change which seems to have been attended with some advantage, though it was with difficulty, and not without many precautions and tedious operations, that an equal colour of sufficient body could be obtained; and then, though highly beautiful, it was not in a state of chemical combination with the fibres of the cotton velvets, for which it was principally used, and therefore was liable to be easily abraded by wearing and friction, especially in those places where it had been folded. Air, however, did not weaken the colour in any degree, nor was it injured by acids.

A little time before this, M. le Pileur d'Apligny announced to the world, that he had discovered the means of dyeing a blue, as far exceeding all other blues in beauty and lustre, as the cochineal scarlet exceeds the common reds. He, however, kept his process secret, until the offer of a premium induced him to make it public. He began it by impregnating the stuffs to be dyed with an iron basis, which he prepared by deflagrating equal parts of old iron and saltpetre in a crucible, afterwards washing the residuum, and dissolving it in vinegar and bran-water. This being sufficiently diluted, was applied as a mordant, in the usual way, to the stuffs, which were afterwards well rinced, and dyed in a preparation of Prussian blue, made by dissolving two pounds thereof (in the moist state in which it is first precipitated) by half a pound of potash, in boiling water, and afterwards adding three ounces of common oil of vitriol, or an equivalent portion of nitric acid, so as to neutralize the alkali, without precipitating the colour. A sufficient quantity of this put into a dyeing

vessel, with hot water, and the stuffs, previously impregnated with the iron mordant, being dyed therein, they became at first green, and afterwards of a beautiful blue colour; which was, however, still liable to take unequally, and, therefore, M. d'Apligny's process, as far as I can learn, has never been carried into any considerable use.

In the thirteenth volume of the "Annales de Chimie," M. Berthollet gives an account of certain ideas which had occurred to him, respecting the defects of all the means used for dyeing with Prussian blue, and of some experiments made at his desire by Mr. Vidmer, of the celebrated calico printing establishment at Jouy, for correcting these defects. It was found by these experiments, that pieces of cotton, impregnated with the acetate of iron, or iron liquor, notwithstanding all possible endeavours to apply it equally, took up the colour of Prussian blue (first dissolved by potash, and then mixed with either sulphuric or muriatic acid) so very unequally, as to leave no hope of success in this way. M. Berthollet accounts for this inequality of colour, by supposing, that one part or particle of iron is sufficient for six of the Prussian colour; and that, therefore, the slightest difference in the *distribution* of the particles of that metal in the mordant, becomes very sensible, when the Prussian colouring matter is afterwards superadded thereto.

Mr. Vidmer was particularly struck with the greens which were produced with the Prussian blue, upon patterns previously dyed olive in the usual way, by the iron liquor and weld, which greens greatly surpassed in beauty all those given by any other means.

M. Berthollet, by experiments which were afterwards made separately from Mr. Vidmer, discovered, that the solution of Prussian blue by lime water, (prussiate of

lime,) succeeded as well as that by potash, and that it required less care respecting the proportions: but he thinks, and with great reason, that the alkaline solution will have the advantage of being afforded cheaper, because when animal matters have been calcined with potash, nothing more will be necessary than to saturate the excess of alkali, by adding to it a little Prussian blue.

M. Berthollet's method was to dilute the prussiate of lime with three or four times as much water, or to dilute with a large quantity of water, a small one of the prussiate of potash, and then to mix with it a little sulphuric acid;* and keeping the liquor at the heat of between twenty and thirty degrees of Reaumur's thermometer, to immerse the cotton, linen, or silk, therein, (having first soaked it in warm water,) and turn it over a winch, &c. as usual, in order that the colour might be equally applied. The dye was found to take sufficiently in a few minutes, and then the stuffs were taken out and washed in cold water. He found the sulphuric acid preferable to the muriatic for this purpose.

Cotton and silk previously dyed grey or brown with galls, or other nigrescent vegetable colouring matters, applied to a ferruginous basis, acquired, by the process just mentioned, a blue colour, proportioned to the depth of the former brown or grey; and those which had been previously dyed olive, by the application of weld, or other adjective vegetable yellows, took also a beautiful green, proportionate to such olive colour. He says no-

* The use of sulphuric acid will be readily understood, by recollecting that alkalies decompose Prussian blue by their greater affinity for its colouring matter than that of the iron, and that this last cannot, therefore, decompose the prussiate of potash, unless its affinity for the iron is assisted by that of an acid for the potash in the way of a double elective attraction.

thing of the effects of this method of dyeing on wool, having made scarce any trials therewith.

Cotton and silk dyed black by the ordinary means, were found, by superadding a blue in M. Berthollet's method, to become more perfectly black, as well where the original colour had faded, as where it had been but imperfectly produced at first. He cautions against using too much acid, as well as against making the dyeing liquor too hot, and keeping the stuffs too long therein, especially the silk, which would thereby lose some of its lustre and softness.

One great defect, however, attending this method of dyeing, especially upon cotton, is, that the stuffs, to which the Prussian blue has been applied, will not bear washing, because, though the colour resists air extremely well, the alkali contained in soap readily dissolves and separates the Prussian colouring matter. As a remedy for this defect, M. Berthollet recommends washing the cottons, dyed by this process, with bran and water, instead of soap, which, he says, will likewise have the advantage of preserving the other colours of printed cottons, or rather of not injuring them, as washing with soap generally does in some degree.

Among the effects mentioned by M. Berthollet, that which I thought the most surprising was, the change of what he (improperly) calls an *olive* colour, *produced by weld and iron liquor*, to a very beautiful green, by the application of Prussian blue in the way before described. The *green*, in this instance, manifestly could not be produced without a mixture of *yellow* with the blue; and weld, the only colouring substance from which it could, in this case, be obtained, never would afford any such colour without the aluminous, or some other basis, very different from iron. I determined, therefore, as soon as possible, to ascertain the truth respecting this

point; and to do it, I took a large piece of cotton, which had been printed in parallel longitudinal stripes, (extending from end to end,) first with a mixture of iron liquor and galls, next with iron liquor only, then with a mixture of iron liquor and the aluminous mordant, (acetite of alumine,) and lastly, with the aluminous mordant only; then followed a white stripe, to which nothing had been applied, and these stripes were alternately repeated, so as to cover the piece. This I dyed in the usual way, with a decoction of quercitron bark, by which the first stripe became black, the second of a dark drab colour, the third of an olive, and the fourth yellow. I then took a solution of potash, fully saturated with the Prussian colouring matter, and poured some of it into a large vessel nearly filled with moderately warm water, and added to it a large proportion of oil of vitriol, (sulphuric acid,) which, from its weight, sunk to the bottom. I took care, however, by stirring, to mix it thoroughly with the liquor, which became uniformly blue, and had a sour taste. I then tore off a transverse strip of the dyed cotton, of the whole breadth of the piece, and immersed it, for a single minute only, in the liquor; when, on taking it out, I found that every particle of the colouring matter of the galls and quercitron bark had been discharged, and *replaced* by the Prussian colouring matter, upon the stripes where an iron basis had been at first applied; nearly according to the quantum of that basis. The first stripe, therefore, instead of being black, was of a very full, deep, strong, blue colour; the second was sufficiently full, though very sensibly weaker; and the third was still weaker; the fourth, to which the aluminous basis only had been applied, was of a very pale bluish colour, almost as slight as the fifth, which had not been impregnated with any basis or mordant. To diminish the excess of sulphu-

ric acid in the liquor, as well as to replenish it with colouring matter, I added thereto a farther portion of prussiate of potash, which being properly mixed, I immersed another strip, torn from the same piece of cotton, and taking it out also, after a single minute, I found that, in this instance, the excess of sulphuric acid had not been so great as to discharge the colouring matter of the galls, though it had totally discharged that of the quercitron bark. I had, therefore, instead of a very dark blue on the first stripe, a very full black, greatly superior to the former black from galls and iron, it having become much more intense by an additional body of blue colour. All the other stripes were very similar to those of the preceeding trial. I then perfectly neutralized the excess of acid in the dyeing liquor, by adding to it a sufficient quantity of prussiate of potash; and a third strip of the same cotton being put into it for the same space of time, I found that none of the colouring matter of the quercitron bark was discharged in those parts or stripes where it had been united to the aluminous basis, though it had been every where decomposed and separated from the ferruginous, and its place supplied by the colouring matter of the Prussian blue. I had, therefore, on the second stripe, a blue colour, instead of the drab which the quercitron bark had produced with the iron liquor; and on the third stripe, instead of an olive, I had a very beautiful green, composed partly of the yellow from the quercitron bark and the aluminous basis, and partly of a fine blue, which the Prussian colouring matter had produced on the same stripe, by uniting with the ferruginous particles of the iron liquor, which had been previously mixed with the acetite of alumine, and applied as a mordant upon that stripe. The yellow upon the fourth stripe remained in full perfection; and the fifth stripe was perfectly white,

having been quite freed from a slight discolouration which the quercitron bark had produced on it in the dyeing vessel. By this, and many similar experiments, made some of them with weld, instead of quercitron bark, I clearly perceived that M. Berthollet must have been mistaken, when he supposed that the olives, which were changed into beautiful greens in the manner before mentioned, had been given by the weld and iron liquor *only*, because no such effect can be produced, either from that or any other adjective vegetable colouring matter, without the aid of alumine, or of oxide of tin, to produce a yellow, whilst the ferruginous basis, by attracting the Prussian colour, produces a blue, the other component part of the green.* I ascertained this fact more completely, by extending my experiments to woollen cloth, of which M. Berthollet says nothing in this respect. I began by dyeing pieces of white broad cloth, some with weld and sulphate of iron, others with quercitron bark and the same sulphate, which, in both cases, produced nearly similar drab colours; and the pieces being so dyed, I immersed them in different portions of diluted prussiate of potash, neutralized with sulphuric acid, a little more than blood-warm, in which they all, after ten or fifteen minutes, became blue; the Prussian colouring matter having decomposed and separated that of the weld and quercitron bark, which, by

* M. Berthollet has since acknowledged his mistake, with becoming candour and promptitude; he says, (tom. ii. p. 319 of the last edition of his Elements, &c.) " Dans cette operation le fer se combine avec l'acide Prussic et forme du *bleu*, pendant que l'alumine fait du *jaune* avec la substance colorante; et *Bancroft a raison*, de combattre l'explication qu'on aurait donne de cette production de vert, dans laquelle on ne fesait point entrer le concours de l'alumine." And he then refers to his Memoir, Ann. de Chimie, tom. xiii.

suitable experiments, I afterwards found to be contained in the several liquors, where the Prussian colouring matter had before been suspended.* If, instead of dyeing the cloth with weld or quercitron bark, and sulphate of iron only, I used alum along with the latter, an olive was produced; and this, being soaked, as before mentioned, in warm diluted prussiate of potash, (neutralized with sulphuric acid,) it produced a beautiful green; the alum and quercitron bark, or weld, furnishing a sufficient quantity of yellow, for that purpose, and the Prussian blue, by its superior brightness, giving the green an increased lustre. In all these, and many other experiments, I found that though the Prussian colour in this way readily decomposed, and separated most of the adjective colours, united to a ferruginous basis, (for which it has a stronger attraction,) it had not any attraction for the aluminous basis sufficiently strong to separate the colouring matters combined therewith: and hence, in all cases where a portion of alumine had been united with iron, to form the basis or mordant, and an olive colour had been thus produced by weld, or quercitron bark, either upon cottons, silk, or wool, a green invariably resulted, from an application of the Prussian alkali with sulphuric acid, unless where this acid was made to predominate so greatly as to decompose, even that part of the vegetable colouring matter which adhered to the aluminous part of the basis.

By reflecting upon these facts, I was led to a method of applying the Prussian blue for dyeing upon woollen,

* This fact affords a remarkable *instance* and *illustration* of the *elective attractions*, subsisting between adjective colouring matters and the metallic oxides, alumina, &c. as we see that, in consequence of these attractions, the *colourable* prussiate was able to separate the colouring matters of weld and quercitron bark, when previously combined with their bases, and *fix itself in their stead.*

silk, and cotton, which seems to me capable of obviating the difficulty hitherto attending its use for these purposes. I have already mentioned M. Berthollet's opinion, that the inequality of colour to which the dyeing with Prussian blue is liable, arises from the difficulty of applying the ferruginous particles alone equally to all the fibres of the cloth; though this may be easily done, when the particles of the iron are combined with those of different adjective vegetable colours; I therefore boiled up what I conceived to be suitable proportions of sulphate of iron with quercitron bark, fustic, and logwood, separately, and then dyed a piece of woollen cloth in each of these mixtures, by boiling it therein for ten or fifteen minutes; I chose these vegetable dying drugs, without any regard to their particular colours, because they are the cheapest, and because they do not contain any mixture of that particular substantive colouring matter found in galls, sumach, &c. which the Prussian colour would be less capable of decomposing and discharging. The pieces so dyed appeared to have imbibed the vegetable colouring matters equally, and as far as I could judge, the ferruginous basis also; and being afterwards immersed in warm diluted prussiate of potash, neutralized by sulphuric acid, they became *beautifully blue;* and though there were some little inequalities in the colour of one of the pieces, I ascribed it rather to my own want of attention to the proper stirring and management of the dyeing liquor, and of the cloth, than in any unavoidable difficulty in giving evenness to the dye. I found also, by subsequent experiments, that some nicety was required to proportion the quantity of the oxide of iron (applied conjointly with the vegetable colouring matters) to the depth of blue colour intended to be dyed upon the cloth; for where an excess of the former was first applied, beyond the portion required to

saturate the Prussian colourable matter, that excess gave the blue a greenish tinge. This, however, may be readily discharged, by passing the cloth through warm water, slightly soured by muriatic acid; though a few experiments would be sufficient to ascertain exactly the quantity of sulphate of iron necessary for producing any particular shade of blue in this way, upon any given quantity of cloth, and thereby obviate all difficulty on this point.* It is necessary always to apply the Prussian colouring matter in a moderate heat, otherwise it will be precipitated by the sulphuric acid, and rendered unfit for this purpose, unless dissolved again by potash, lime, &c.†

* I found afterwards, that the sulphate of iron would afford a sufficient basis for between sixty and an hundred times its weight of cloth, according to the fulness of the blue intended to be dyed.

† Encouraged by the apparent success of these experiments, I have several times, since the former edition of this volume, renewed my attempts to render the Prussian blue available for dyeing broad-cloths, believing, from *the incomparable beauty of its colour*, and the constancy with which it resists all impressions from the sun and air, as well as of acids, that it might become an important acquisition, though unfit to withstand the action of soap; to which, indeed, broad-cloths are but rarely subjected. But though I have, in many instances, dyed pieces of cloth, of the size of those upon which my experiments are commonly made, (i. e. from six to twelve inches square,) with a perfect evenness of colour, and with indescribable vivacity and lustre; I have, also, frequently failed to attain the requisite *equality* in the colour; and it has seemed to me that the extreme brightness of the blue, dyed in this way, has contributed to these failures, by rendering the *slightest inequalities strikingly perceptible.* I have now before me some of the pieces of cloth so dyed, and though the colour of several of them is intensely full, its lustre greatly surpasses every thing before seen in wool, and emulates even the *transparency* and brilliancy of the finest sapphire, to such a degree that the eye, which has once seen the Prussian blue, so communicated, disdains afterwards to fix itself upon the common indigo blue. The seeming difficulty of giving the former of these colours with sufficient *evenness*, to a

I shall offer something more respecting the use of Prussian blue for dyeing a most beautiful *green* upon woollen cloth, when I come to treat of the properties of quercitron bark.

To ascertain whether any affinity existed between the aluminous basis and the colouring matter of Prussian blue, I took a piece of cotton, which had been printed with the aluminous mordant, and cleansed as usual for topical dyeing, and immersed it in warm diluted prussiate of potash; seeing, however, at the end of fifteen minutes, that it had acquired no colour, I put into the liquor a small proportion of a solution of iron by muriatic acid, which rendered it blue, and the cotton soon became of that colour pretty equally, without any manifest difference of colour in the places to which the aluminous mordant had been previously applied. Taking the cotton out of this dyeing liquor, I tore off a bit of it, and washed it with soap, which soon discharged all the colour, excepting where the cotton had been impregnated with alumine, and there it was considerably weakened, though enough remained to show that it had been attracted and rendered more fixed by the aluminous basis. Another bit of the same cotton was immersed in a solution of carbonate of ammonia, (mild volatile alkali,) which having a power of decomposing the Prussian blue, I supposed it would weaken, if not wholly discharge the colour. To my surprise, however, I found that it greatly augmented the blue, which before was rather pale, and gave it almost the appearance of what is called garter blue; an effect which will, perhaps, be the less surprising, if we consider, that vola-

whole piece of cloth, has, indeed, hitherto restrained me from attempting to do it; but I am not without a strong hope of its being ultimately performed.

tile alkali, like the Prussian colouring matter, is an animal production, and that, excepting the carbon of the latter, both are composed of the same principles.

Another bit of the same cotton being put into water, very slightly tinctured with a solution of copper by volatile alkali, the blue colour, in a very sudden and surprising degree, augmented to an intensely deep garter blue, or violet, much exceeding that produced by the ammonia alone; and this being afterwards washed with soap, the colour of those parts where the aluminous mordant had been at first applied, was still better fixed than it had been on the like parts by the volatile alkali alone in the preceding trial.

Another piece of the same cotton being immersed in water, with which a very little muriate of copper had been previously mixed, soon became of a deeper blue, but without any of the purple or violet hue which had been produced in the two preceding instances.

This piece being afterwards washed with soap, I perceived that the colour where the aluminous mordant had been applied, was still much more firmly fixed than it had been by any other means. Indeed, after a severe washing, which completely discharged the colour every where else, the spots or parts impregnated with alumine retained a full strong blue, which the soap had, indeed, turned a little towards a violet colour; but, after being well rinced in clean water, it returned again to its proper complexion, and stood a long exposure to weather unaltered, and afterwards two or three severe washings with soap, without much diminution of colour.* It

* In this and the other pieces, the blue upon the spots impregnated with alumine, after it had been weakened by washing, was rendered nearly as strong as ever, by dipping them into water, slightly soured with sulphuric acid, so as to decompose and neu-

must, however, be remembered, that if copper thus manifestly fixed the Prussian blue, it was only in those parts where the aluminous mordant had been at first applied; since the other parts of the cotton were washed white with as much facility as they were on the bit to which nothing had been applied after it became blue; so that, doubtless, both the alumine and copper together, greatly contribute to fix the colouring matter of Prussian blue. The copper, indeed, as we shall presently see, possesses a power of uniting therewith, and producing one of the most permanent of colours, even upon linen and cotton; a fact which, I believe, never was imagined by any one, until it very lately fell under my observation. From these proofs of the utility of an aluminous basis in fixing the Prussian blue, it would, I think, prove advantageous to prepare woollens by the usual boiling with alum, or alum and tartar, before they are dyed with copperas and quercitron bark, fustic, or logwood, for a Prussian blue. But in this case it would be necessary to mix a greater proportion of sulphuric acid in the prussiate of potash, or of lime, in order that an excess of acid may assist in discharging these vegetable colouring matters, otherwise, instead of a blue they would produce a green; or a black, where logwood had been employed with the sulphate of iron.

Having soaked pieces of silk and of cotton in the diluted prussiates of potash, soda, lime, and ammonia, or volatile alkali, separately, and afterwards dried them, I applied to each, by the pencil, a little of the solutions of all the metals and semi-metals in different acids, and also in alkalies, where they were soluble in the latter, in

tralize the alkali which had been imbibed from the soap in washing; perhaps the acid also restored the oxygene which had been separated by the soap.

order to see the effects of all these several bases upon the Prussian colouring matter. I should tire the patience of my readers, were I particularly to describe the results of these different combinations, especially as no words could give adequate ideas of the great variety of shades and degrees of colour, and particularly of the blue produced by them, which varied extremely in fulness and brightness, as well as in its inclination towards the purple and violet on one hand, and green on the other; and, indeed, the diversities of blue only, (which was the colour produced by much the greatest number of metallic solutions,) would alone constitute a very pleasing variety of colour in the way of printing upon silk or cotton. There were, however, several other colours produced at the same time; *e. g.* the nitro-muriate of gold produced a very beautiful green, inclining a little to the yellow, which, by washing, changed somewhat to the olive, whilst the nitro-muriate of platina produced a green, inclining to the blue. The nitro-muriate of cobalt produced a grass green; the nitrate of mercury, a greenish yellow; and the nitrate of nickel, an olive brown.*

* As I have not abstained from correcting what has appeared to me erroneous, even though sanctioned by Newton in Optics, and Berthollet in Chemistry, it is my duty, with still greater promptitude, to detect, avow, and correct, my own errors, as far as I am able; and I therefore declare, that I was deceived when I supposed that the Prussian colourable matter had produced *blue* colours of different shades, in consequence of its combination with other metallic bases, besides that of iron. In the experiments just described, I had employed a prussiate of potash, in its mild state, without being sufficiently aware of the quantity of the oxide of iron, which it held in solution. Some of the metals also, and particularly the zinc, antimony, and manganese, contained iron, as is frequently the case; and some of the acids employed to dissolve them, contained it also, as frequently happens. From all these sources of error, of

But the most remarkable, and, probably, the most useful effect of these applications was, a very full, striking, lively colour, of which I cannot by words give my readers a perfect idea, because I do not remember to have ever before seen any colour exactly like it, and there is, I believe, no name in any language suited to it. It approaches nearest, however, to the highest and brightest colour of new copper, but inclines more to the red, and is accompanied with a kind of metallic shining lustre, which, in my eyes, appeared very agreeable. This colour (which I shall call the red prussiate of copper, until a better name be given to it) was produced by the different solutions of copper in the sulphuric, the nitric, the muriatic, and the acetous acids, separately; and particularly well by that in volatile alkali. But the most remarkable circumstance attending the production of this *new* colour, was its extraordinary permanency, which was such, that though all the alkalies decompose the Prussian colourable matter when combined with iron, they have no effect upon its combination with copper; and the stability of the new colour is such, that neither acids,* nor washings with soap, however nu-

which I ought to have been more mindful, I ascribed, as Fabroni and many others had done, the property of giving a blue colour with Prussian colourable matter, (which, as far as I know, belongs only to iron,) to metals which do not possess it.—Could I find *that property* in any *other* matter, I should eagerly recur to, and make trials of it, in the hope of being thereby enabled to communicate and fix the blue, under consideration, upon broad-cloth, &c. with greater evenness than has yet been found practicable, with the basis of iron.

* I have since found, that by twenty-four hours immersion in the oxymuriatic acid, this colour was nearly decomposed; the Prussian colour being mostly separated, and the oxide of copper made green. But this fact affords no reason to doubt of its permanency for all

merous, nor exposure to weather for the longest space of time, seem capable, in the least degree, of diminishing either its body or its lustre; and, therefore, I cannot help thinking, that it may prove highly useful, and more especially for calico printing, by way of *topical* application upon cottons, and, perhaps, in dyeing cotton-yarn for stripes of muslins, borders of handkerchiefs, &c. I have not experienced the same effect by applying a *direct* mixture of the Prussian colouring matter with a solution of copper, not even when I put the prussiate of ammonia into a solution of copper by ammonia, (which I thought most likely to answer); but have always found it necessary, either to apply the Prussian colouring matter (dissolved by potash, soda, ammonia, or lime) *first* to the linen, cotton, or silk, and after suffering it to dry, to apply some one of the before-mentioned solutions of copper; or else to apply the metallic solution first, and then the prussiate; but in this last method, I have not found any solution of copper answer so well, unless it be that by ammonia, or volatile alkali.

Some years after the publication of my discovery of the red prussiate of copper, it engaged the attention of M. Proust, who satisfied himself, as I have since done, that to produce this red colour, it is necessary to impregnate the colourable Prussian matter, or a prussiate of

the useful purposes in question. I found also, that a nitrate of silver, which contained a little intermixture of copper, being dropped upon cotton, stained or impregnated with the red oxide of copper, changed it to a beautiful greenish yellow; and that a nitro-muriate of gold, applied to cotton so stained, changed it to an orange. This, and the former pieces of cotton being dried, and afterwards washed with soap, that to which the nitro-muriate of gold had been applied, assumed a deep violet, and very fast colour; and that with the nitrate of silver, became green, probably in consequence of the copper, by which the silver had been alloyed, and that contained in the red prussiate of copper.

potash, or lime, or ammonia, with that portion of *black* oxide of iron, which has been already mentioned, as necessary to enable the *red* oxide to become *blue*,—and that a simple prussiate, destitute of the black oxide, though it unites with the oxides of copper, will only produce a yellowish brown colour; and I think, from my own experiments, that the colour in question is made to approach nearer to the *blood-red* by a little increase of the proportion of black oxide, beyond what would strictly be necessary to produce a Prussian blue with the red oxide of iron.*

With cobalt the simple prussiate gives a cinnamon brown, less approaching to the blood-red, than the prussiate of copper with the black oxide of iron: with an oxide of mercury this prussiate gives a *yellow*, sometimes inclining to the olive; and with gold, it gives a fine yellow. Having nothing more to offer concerning *animal* adjective colours, I shall next proceed to *vegetable.*

* About the year 1802, the Journals of the Royal Institution, and several periodical works, announced that Mr. Hatchett had *discovered* a very durable and useful *pigment* in the prussiate of copper, and without any mention of my name, though I had, ten years before, not only discovered this pigment, but what was of much greater difficulty and importance, the ways of fixing it permanently, by topical application, upon linen, cotton, silk, &c., and had published my discovery eight years before, in a volume, of which one thousand copies were in the hands of the public.—I hope I shall not be thought improperly anxious to do myself justice on this subject, when it is considered, that I have suffered ten years to elapse without any mention of it, even in private conversation.

EXPERIMENTAL RESEARCHES

CONCERNING THE

PHILOSOPHY

OF

PERMANENT COLOURS.

PART III.

Of Vegetable Adjective Colours.

CHAPTER I.

Of the Reseda Luteola, Linn., or Weld Plant, and some other Vegetable Yellows.

"Lutei video honorem antiquissimum, in nuptialibus flammeis totum concessum: et fortassis ideo non numerari inter principales, hoc est, communes maribus ac fœminis, quoniam societas principatum dedit."

C. Plinii secund. Hist. lib. xxi. 8.

BY this quotation from Pliny, we learn, that the *yellow* dye, though highly esteemed from remote antiquity, was exclusively appropriated to the use of women, and that the *veil* which brides wore on the wedding day, was entirely of that colour.

The weld plant seems to have been employed to dye *yellow*, at least as early as the time when Virgil wrote his Eclogues; for the *lutum* mentioned in his fourth, (line 44,) was, doubtless, the reseda luteola, which grew wild in Italy, as it does now in various parts of Europe; though the cultivated plant, which is smallest, abounds most in colouring matter. There are some varieties of

this plant; and of these one was formerly put into my hands, which had been imported from Hamburgh; of which the stalks were not a fourth part so tall, or so large, as those of the plants cultivated in England and France. I did not, however, discover any considerable superiority in the *quality* of its colouring matter, though in regard to *quantity* it yielded more than four times as much as an equal weight either of English or French weld. This smaller variety, according to my information, grows, and is used by the dyers, in several parts of Germany.

Weld requires the growth of nearly two summers before it comes to maturity, and the crop is besides liable to fail from so many causes, that it cannot be a desirable object of agriculture in Great Britain. Indeed, it will not come to maturity in the northern parts of this island, and the expense of transportation is so great, by reason of its bulk, that the calico printers of Lancashire, Carlisle, Glasgow, &c. could not have exercised their art, either so advantageously or so extensively as they have done, if my discovery of the properties and uses of the quercitron bark, (to be mentioned in the next chapter,) had not come to their relief, and moreover afforded them other important benefits.

To give a full yellow colour to wool or silk, twice its weight of either English or French weld is deemed necessary; and from the extent of space which the stalks of the plant occupy, (the roots being useless,) it is necessary to extract the colour separately, previous to the dyeing operation; which, however, must take place soon after such extraction, as the decoction will otherwise speedily undergo a decomposition, sufficient to render it useless.

The old book translated from the Dutch, and printed, as before mentioned, in 1605, directs the employment

of stale urine and wood ashes with water, to extract the colouring matter of this plant, which was afterwards to be fixed on linen by verdigrise instead of alum, though the latter appears to have been employed as the mordant for wool; and this practice seems to have subsisted ever since, with but little alteration.

Wool, or woollen cloths, are commonly prepared for the weld yellow, by boiling them the usual time with a fourth or fifth of their weight of alum, and a twentieth of their weight of tartar; which last is supposed to render the colour a little more delicate and lively; and the yellow may be farther improved by adding, either to the preparation, or the dyeing liquors, a small portion of the muriate, nitro-muriate, or murio-sulphate of tin.

Linen thread, or cotton yarn, are commonly prepared for the weld yellow, by copious impregnations with the aluminous basis, to which a little lime or chalk is sometimes added; a little powdered verdigrise is also sometimes mixed in the *dyeing* or weld liquor.

Weld appears to contain a large portion of potash, neutralized chiefly by phosphoric and malic acids.

In topical dyeing, or calico printing, very little less than the heat of boiling water, will suffice to fix the colouring matter of weld; and the parts wanted to be kept white, are then so much stained by it, and this stain is so difficult to remove, that, during the damp cloudy weather which generally prevails in winter, four or five weeks exposure on the grass will hardly prove sufficient for that purpose. This is a serious inconvenience which does not attend the use of the quercitron bark, and which has caused the latter to be generally employed by calico printers to almost the total exclusion of the former; though, it was their only resource for dyeing yellow, until the recent introduction of quercitron bark.

Weld also produces another bad effect when employed

for topical dyeing upon linens or cottons, which have previously received madder colours; for in this case, the *weld yellow*, by a particular affinity, applies and fixes itself upon these colours so copiously as to change their appearance, and tarnish their lustre greatly; and this is another defect, from which the bark is nearly, if not wholly, exempt.*

By the Act of the thirteenth of his present Majesty, ch. 77, the sum of 2000*l.* was granted to Dr. Richard Williams, as a reward for his invention of a fast green and yellow dye on cotton yarn, and thread. This supposed fast dye was given with weld, by the help of a mordant; the composition of which (that foreigners might not enjoy the benefit of it) Dr. Williams was permitted to conceal, and to supply the cotton and thread dyers with the mordant at a certain price. I have, however, reason to believe, that it was either a solution of tin alone, or of tin and bismuth, which enabled the weld yellow, as it enables that of the quercitron bark, to bear the action of acids and of boiling soapsuds, though unable to bear the action of sun and air. This defect, however, was not readily discoverable by the method which Dr. Williams employed to obtain a favourable testimony from the dyers on this subject. His method was that of weaving the dyed yarn into pocket handkerchiefs, so as to produce yellow stripes or borders, and giving them to be worn in the pockets of those who were afterwards to attest the goodness of

* The opaque yellow, employed for paper hangings, is obtained by mixing clean white calcareous earth, with a solution of alum, sufficient in quantity to convert the former into a saturated sulphate of lime, which subsiding along with the alumine, forms a basis for the colour; and this basis is made yellow by applying to it a strong decoction of the tops and seeds of the weld plant, and it is afterwards dried and formed into cakes.

his dye and as handkerchiefs inclosed in a pocket are not exposed to the sun and air, the defect in question was not perceived until some time after the reward had been paid for a supposed invention of no value, and of which, I believe, no use is now made.

Art. 2d. Rhus cotinus, Linn. or Venice sumach, improperly called *young* fustic, is a shrub growing principally in Italy and the south of France; whence the root, as well as the stem or trunk of the shrub, deprived of the bark, are brought and employed (after being chipped) for dyeing a full high yellow, approaching to the orange, upon wool or cloth, prepared either with alum or the nitro-muriate of tin. But the colour obtained by these means has been always deemed very fugitive. I find, however, that this defect, in regard to the last of these mordants, may, in a great degree, be obviated, by employing *tartar* along with the nitro-muriate of tin. Four pounds of the rhus cotinus chipped, afford no more colour than one pound of the quercitron bark. This appears to be the shrub mentioned by Pliny, (lib. xvi. cap. 8.) as growing in the Appenines, and called *cotinus*.

Art. 3d. The rhus coriara; elm-leaved, or common sumach of Spain, Portugal, and other parts of Europe, as well as of North America, affords a yellow dye with the aluminous basis; but so pale that it is but little employed for the purpose of giving a yellow colour only; it, however, possesses another species of colouring matter, similar in most respects to that contained in galls, which renders it useful for drab and dove colours in calico printing, and also capable of dyeing black with iron and the solutions of that metal: this species of colouring matter, and the application thereof, upon wool and cotton, will be treated of in their proper places. The principal uses of sumach with quercitron bark, in

calico printing, will be noticed in the next chapter. Employed by itself in this way, it gives a troublesome stain to the white parts, which is obviated by using it with the quercitron bark, and it is diminished when used by itself, by employing only a very moderate heat, in which calico, printed with acetate of alumine and iron liquor, of different degrees of strength, will receive yellow, black, and grey colours, sufficiently lasting.

There are several other species of sumach, which grow spontaneously and abundantly within the United States of America, and produce colours similar to those of the rhus coriara; particularly the rhus glabrum, called scarlet sumach, from the colour of its acid berries, which are produced in clusters, and used by the aborigines of North America as *mordants* to fix the red colour of a species of gallium, with which they have long dyed their porcupine quills; also the rhus typhinum, called Virginian sumach, the rhus copallinum, or lentiscus-leaved sumach, &c.

The bark of the roots, stems, and woody branches of all these shrubs contains a large proportion of that species of colouring matter, which gives a black colour with iron, and which was erroneously supposed to distinguish and belong exclusively to what have been called astringent vegetables: but for *dyeing yellow*, the colouring matter of the leaves and young green shoots is greatly preferred; and in the countries where sumach is cultivated for the use of dyers, the stems are never allowed to become woody, the young shoots being cut down every summer, and ground up with the leaves.

I formerly endeavoured to concentrate the colouring matter of sumach (with the tannin which accompanies it) by reducing it to the form of a dry extract, for the use of dyers and tanners, but I found it strongly dis-

posed to deliquate or attract moisture; probably, from the *målic* acid which seems to abound therein.

In regard to the colouring matter of the *wood* of the large stems of the old full-grown shrubs, it seems, in all the species, to resemble that of the rhus cotinus, (Venice sumach or fustic,) mentioned in the preceding article, and in my experiments has produced exactly similar effects.

Pliny mentions (lib. xxiv. c. 11.) the leaves of sumach, which he calls rhus erythros, as being employed instead of pomegranate rinds to prepare skins, (leather), and the berries as being used instead of salt, to preserve and season, or give relish to meat—and the savages of North America formerly employed the berries of their scarlet sumach for the same purposes.

Art. 4th. Morus tinctoria, Linn.* called improperly *old fustic* by the English, and bois jaune by the French, is a large tree growing naturally in Jamaica, Porto Rico, Tobago, and almost all the other West India islands; its wood is of the colour of sulphur, and has, within two centuries, been brought into general use as a dyeing drug, though the yellow colour, which it affords with an aluminous basis, is neither high nor bright; it has, however, the advantage of being durable, and of not being thrown down or made latent by acids so much as the weld and quercitron yellows; and for this reason it is now very commonly employed (chipped or ground) in dyeing Saxon greens upon cloth, with the sulphate of indigo; the muddiness of its yellow being of but little

* The fruit of this tree in size and shape resembles the white mulberry; and like other mulberries, has its *acini* both within and without the pulp, which are of a greenish colour. Whilst unripe, the fruit is milky; but at maturity it is lusciously sweet. Birds feed on the fruit, and by dispersing, plant the seeds.

detriment to the full dark greens most frequently dyed with it in this way.

It is also very much employed for dyeing drab colours upon cloth, and especially on cotton-velvets, fustians, &c. with an iron basis, and olives with a mixture of this and of the aluminous basis, as will be mentioned in the succeeding chapter, where so much will be found respecting the means and modes of employing the quercitron bark to produce similar colours, which it does with equal advantage, that I shall add but little more upon this subject. Four pounds of this wood chipped, yield about as much colouring matter as one pound of the quercitron bark; and allowing for this difference of quantity, it may be employed for general dyeing with the several mordants or bases proposed for the bark; remembering always that the yellow colour which it affords, can never be made to acquire any thing like an equal degree of clearness and brightness with that of the bark or of the weld; and for this, with some other reasons, it is not likely to be ever employed in calico printing.*

I am not yet able to ascertain whence the word fustic was derived to our language. Venice sumach appears to have been long distinguished in France by the name of *fustet*, and I suspect that our dyers with the wood, introduced the name, and changed it to *fustic;* such changes having frequently happened in other cases. The morus tinctoria being afterwards brought from America, and also employed for dyeing yellow, and being destitute of a name, appears to have likewise acquired that of fustic; and a confusion having arisen by thus giving the same name to two different species of wood, a distinc-

* Since this was first printed, M. Chaptal has found means, which will be mentioned presently, to obviate the muddiness of this yellow, in a great degree.

tion was improperly created by calling that of the Venice sumach, *young* fustic, (as being manifestly the wood of a small shrub,) and that of the morus tinctoria, (which is always imported in the form of large logs or blocks,) *old* fustic. At what time these epithets were first applied, to create this distinction, I have not discovered; but they must have been in general use, at least one hundred and thirty years ago; because Sir William Petty, in an account "of the Common Practices of Dyeing," which he gave to the Royal Society when first instituted, mentions Venice sumach under the name of "*young* fustic," and the morus tinctoria under that of "*old*," as being their common and appropriated names. In this way, however, many persons have been misled so far as to conclude, that two very distinct dyeing drugs (the one a small *European shrub* of the sumach kind, and the other a large *American tree* of the mulberry kind,) were the same, or differing from each other only in *point of age*. The French have, indeed, avoided this source of error, by leaving the Venice sumach to bear exclusively the name of *fustet*, and giving that of bois jaune, or yellow wood, to the morus tinctoria; and, perhaps, it might be well for us, even now, to call the latter *yellow wood*, or *dyer's mulberry*, in order to avoid the error in question.

This wood, like some others, contains both a resinous and an extractive colouring matter, and both appear to be mixed with a portion of *tannin*, or the tanning principle, which tarnishes the yellow of the colouring matters, and M. Chaptal has lately found (See Mem. de l'Institut, tom. i.) that glue, when added to a decoction of this wood, precipitated the tannin, and thereby enabled the superincumbent liquors to dye yellows almost as bright as those of weld and quercitron bark.

The wood known in England by the name of green ebony, possesses a species of yellow colouring matter very similar to that of the morus tinctoria in dyeing, and is sometimes employed in its stead.

Art. 5th. The unripe berries of the rhamnus infectorius of Linnæus, are called French berries, and chiefly employed for preparing a lively, but very fugitive, yellow for topical application in calico printing.* Cotton printed with the aluminous mordant, and dyed with these berries, instead of weld or quercitron bark, receives a full bright yellow; but in this and every other way it fades so speedily, that the use of it should not be tolerated, whilst there are other means of giving much more durable yellows. There is a particular species of the rhamnus, growing in Candia, and other parts of the Levant, yielding berries larger than those brought from the South of France; they are distinguished by the name of Turkey berries, and preferred to the French, though the colours of both are fugitive. Great quantities of them are exported from Salonica, to which they are brought from Thessaly and Albania.

Art. 6th. Saw-wort, serratula tinctoria, Linn., affords a good substitute for weld in dyeing upon the aluminous basis, with which it communicates a bright lemon yellow of considerable durability. The common preparation with alum and tartar, is to be employed for this yellow upon wool and cloth; or if a brighter colour be

* M. Duhamel asserts, that the French berries, or grains d'Avignon, are produced by the rhamnus infectorius, which (as well as the rhamnus saxatilis and other species) certainly produces berries giving a yellow colour. But professor Martyn, in his Edition of Miller's Gardener's Dictionary, contends that these berries are the fruit of the narrow-leaved alaternus, a shrub which grows abundantly in the South of France; and he asserts, that having collected its berries, and shown them to several dealers in the article, they offered to buy them as French berries.

wanted, the preparation may be given with nitro-muriate of tin, (dyer's spirit,) and half as much tartar.

For giving a very inferior yellow upon coarser woollens, the dyer's broom (genista tinctoria, Linn.) is sometimes employed, with the common preparation of alum and tartar.

Art. 7th. All the five species of erica, or heath, growing on this island, are, I believe, capable of affording yellows much like those obtained from the dyer's broom —their colours may, indeed, be raised and brightened by the solutions of tin; but when this has been done, they have, with me, always proved fugitive. This I have also found to be the case of the yellow, dyed with the bark and shoots of the Lombardy poplar, (populus dilata, or pyramidalis,) recommended by Mons. d'Ambourney, though they are poor in colouring matter, seven pounds weight of them being required to dye a single pound of wool.

Art. 8th. The American golden rod, (solidago canadensis, Linn.) affords good yellows to wool, silk, and cotton, upon the aluminous basis. Hellot seems to have been the first who attempted, though without success, to introduce this plant into general use as a yellow dyeing drug; and Messrs. Gaad and Succow have since made the like attempts with no better success; though I can affirm, from the results of many trials, that it would prove a very advantageous substitute for the weld in calico printing; the colour which it affords in this way, to parts printed with the aluminous mordant, being in no respect inferior, and the stain or discoloration produced upon the unprinted parts, being much less and much more easily discharged than that of weld. The plant (golden rod) is also more rich in colour, and capable of being raised with great ease. It grows naturally

in abundance, almost every where, between Carolina and Hudson's Bay.

Kalm says, that the three-leaved hellebore, (helleborus trifolius,) called tissavoyanne jaune, by the French in Canada, is there used by the Indians in giving a fine yellow colour to several kinds of work, which they make of prepared skins; and that the French having learned this from them, dye wool and other things yellow with this plant.

Besides these, there are many other vegetables capable of affording adjective yellow colours, both with the aluminous basis and that of tin, particularly the seeds of purple trefoil, lucerne, and fenugreek, the flowers of French marygold, the chamomile, (anthemis tinctoria,) the ash, (fraxinus excelsor,) the fumitory, (fumaria officinalis,) the leaves of the sweet willow, (salix pentandria,) the verbascum thapsus, Linn., the agrimonia cupatoria, or common agrimony, the bidens tripartita, or trifid water hemp agrimony, the leaves and branches of the lemon tree (citrus,) and others, which need not be named, because they are not likely to be ever considerably employed. Besides these, Loureiro mentions the fibraurea tinctorea, a climbing shrub, and pterocarpus flavus, a large tree, both growing in the woods of China and Cochinchina, and affording yellow dyes; as does the fruit of the gardenia florida. He also mentions the roots of the morinda umbellata, as being employed in Cochinchina to dye cloth of a permanent saffron colour.

Ventenat has described a species of tagetes (papposa,) growing on the banks of the Mississippi, and affording, as he says, a durable yellow dye.

The Elder Michaux observed in the western division of the Tennessee country, (North America,) a species of sophora, nearly related to the sophora japonica, em-

ployed by the Chinese as a yellow dye, and conceived that it might become an object of great importance. The younger Michaux adopting this idea, sent a parcel of the wood to M. Chaptal, then Minister of the Interior in France, and he soon after gave me a sample of it, (when I met him in South Carolina in the year 1802,) which, though it had been purposely made very small, enabled me to satisfy myself that it could never maintain any sort of competition with the quercitron bark.

Professor Woodhouse, of Philadelphia, mentions the hydrastis canadensis as imparting to silk "a rich and superb yellow colour," and he afterwards gives an account of many experiments which he had made with the xanthoriza tinctoria, but concludes it by stating as his opinion, that, "that truly valuable dyeing drug, the *quercitron* bark, will always supersede the xanthoriza, *and every other native* (i. e. American) yellow dye."

There is, indeed, so much difficulty in always producing the exact shades of colour which dyers are required to imitate, that the use of *various* materials for obtaining *similar* effects must always prove highly inconvenient. A few drugs occupying but little space, rich in colouring matters, and capable of being always obtained, as well as extensively applied, by saddening and otherwise diversifying their respective colours, are to the dyers most needful and useful: by being constantly occupied with a few such drugs, they acquire that degree of dexterity and certainty in the use and management of them, which alone can prevent disappointment in the nice operations of this art.—Such a drug is the quercitron bark, which will be the principal subject of my next chapter.

CHAPTER II.

Of the Properties and Uses of Quercitron Bark.

"Il n'y a pas de proprieté plus respectable que les decovertes de l'industrie."
BERTHOLLET, *Ann. de Chimie, tome* vi.

THE *Quercitron* bark is produced by the quercus nigra of Linnæus,* which might now be more properly denominated quercus tinctoria;† and is one of the

* The name of *quercitron* was given by me to this species of oak, and derived from the Latin words, quercus *citrina*, which I thought more suitable than the denomination of Linnæus: and being so given, the name was adopted and sanctioned by an Act of Parliament, of the 33d year of his present Majesty, (entitled an act for allowing the importation of quercitron, or black oak bark, &c.,) and it has become the prevalent name in France, Germany, and other parts of Europe.

† Since this was first printed in 1794, the elder Michaux has adopted the name of quercus tinctoria, in his " Histoire des *Chenes* de l'Amerique, ou description et *figures* de toutes les espéces et variétés de chenes de l'Amerique septentrionale, &c. par André Michaux, Membre Associé de l'Institut National de France, &c." Paris, 1801, folio. In this work the author describes twenty species of American oaks, of which his thirteenth is that which affords the *quercitron* bark. His character of it, is " Quercus foliis petiolatis, subtus pubescentibus, lato-obovalibus, leviter, et subrotunde lobatis, basi obtusis: cupula subscutellata, aut turbinata; glande depresso-globosa aut ovata."

Of this species he makes two varieties.

1st. " *Chene Quercitron*, a feuilles angulensis,—great black oak —Champlain black oak." He represents this tree as growing from lake Champlain to Georgia, always in a good soil, and at some distance from the sea; and as rising from sixty to eighty feet high, with a trunk from six to ten feet in diameter, in Georgia; but smaller northward. This is the variety which I have endeavoured *exclusively* to introduce as a *dye*. His second variety is "Chene quercitron a feuilles sinueuses." Having sinuated leaves, and growing chiefly in the *low* parts of Georgia and South Carolina. The yellow colouring matter of this species is combined with another, which gives a brownish tinge, or tint, called *fauve* by the French; a circumstance in which it agrees with what I suppose to be the quercus aquatica, or *water* oak, of Catesby.

objects of a discovery, of which the use and application for dyeing, calico-printing, &c. are exclusively vested in me, for a term of years, by an Act of Parliament passed in the 25th year of his present Majesty's reign.*

* About four years after *this* paragraph was written and published, the *term* of the *act* in my favour expired; but as I had, during its continuance, exercised my rights more liberally and beneficially for the public, than providently towards myself and family, and as I had, moreover, been frustrated of a great part of my just profits, by various infringements of this act, and by obstructions and losses resulting from the war, a bill was introduced, and *passed* by the House of Commons, in the 39th of his present Majesty, "*for enlarging, for the term of seven years, and continuing the powers*" of the *former act* in my favour: This bill (or act of the House of Commons) was, however, lost in the House of Lords, by a *postponement* of the second reading, in consequence of the opposition of a great number of persons in the Northern parts of the kingdom, who had greatly profited by my discovery, and of whom some had grown rich and powerful in a considerable degree from it. And thus, without being heard by my counsel, who were in attendance, or being allowed to repel, as I was prepared to do by adequate testimony, the groundless allegations of my opponents, and though more than three-fourths of the Calico Printers, and consumers of the quercitron bark, in *the Southern parts* of the kingdom, had petitioned the House of Lords *for the prolongation* in question, I was left with *very little* remuneration for the labours of a great part of my life; excepting the consciousness of having done good to many persons, who appeared to be neither sensible of, nor grateful for it. I have, however, long since forgiven my opponents. Most of them had been made to believe that my profits were five times greater than they were in truth; and that their own interests would be greatly promoted by this termination of my rights; though many of them had previously certified under their hands, that the advantages resulting from my discovery had been greatly increased by the beneficial manner in which these my rights were exercised: and this fact was strongly asserted by the petition, just mentioned in my favour, in which the Petitioners declare that they "have never experienced any inconvenience from the exercise of any of the rights vested in Dr. Bancroft, by the act formerly passed in his favour; but, on the contrary, are convinced that they have been inva-

The bark of this tree appears to consist of three parts or coats. *

riably exercised upon a plan of all others the most conducive to the public good, and at the same time with such liberality, that the inconveniences usually attending monopolies have been thereby avoided." "That although dyeing-woods and drugs from America have generally risen since the war began, and some of them to more than five times their former prices; and although, from the great abundance of colouring matter in the quercitron bark, and its useful properties, joined to a great addition to the cost thereof, and more especially to the freight and charges attending its importation during the last six years, Dr. Bancroft might have been entitled and enabled to advance the price of the said bark, in a proportion at least, equal to that of other dyeing drugs, or woods from America, yet he has invariably supplied your Petitioners, and other consumers thereof, at the *very lowest price*, to which it had been reduced by him before the present war, and by so doing, has relinquished the fair profits of his invention, to a greater amount than any profit which he is likely to make, by supplying this bark for a farther term of seven years, at the low price intended to be fixed for the same, by the bill in question."

The Petitioners moreover declared themselves "fully persuaded, that it would be *safest and most advantageous* for themselves, and other consumers of the quercitron bark, to continue *secured* of sufficient supplies thereof, during a farther term of seven years, at the *low* price intended to be fixed for the same by the bill in question, and thereby exempted from those frequent variations and augmentations of price, which might otherwise be expected, so long, at least, as the war should continue, by the practices of those who, from time to time, might find means to engross the said bark."—That this persuasion had been well-founded, was soon proved by the event, for in less than twelve months this bark rose to three times the price at which it had been invariably supplied by me, and at which I should have been bound to supply it, for another term of seven years, if the bill had become a law; and it has on the average been at nearly double that price to the present time.—This is the *only instance*, I believe, in which an invention ever became more *costly*, after the expiration of a monopoly, granted to remunerate the inventor, than it was during the continuance thereof, and it has *demonstrated*, most *incontrovertibly*, that my opponents were greatly *deceived*, *and that* I was greatly wronged.

1st. The epidermis, or external coat, through which the several excretions of the tree are transmitted, which, in part at least, adhere to its outer surface, where they harden, and become almost *black*, by condensation, and probably by an absorption of oxygene; and hence the Linnæan denomination of *black* oak has originated; that great naturalist having had no knowledge of the properties of this bark in dyeing.

2d, The middle or cellular coat, in which the colouring matter principally resides; and,

3d, The interior or cortical part, consisting chiefly of lamina, formed by the re-union of different vessels, which become more hard and fibrous, as they are placed nearest to the woody part of the tree, and have, therefore, less room to contain the colouring matter.

The epidermis, or exterior blackish coat of this bark, affords a yellow colouring matter, which, however, is less pure, and more inclined to a brownish hue, than that of the other coats or parts; and it ought, therefore, to be separated by shaving. When this is done, and the remaining cellular and cortical parts are ground by mill-stones, they will separate partly into a light fine powder, and partly into stringy filaments or fibres, which last yield but about half as much colour as the powder, and, therefore, care should be always taken to employ both together, and as nearly as possible in their natural proportions, otherwise the quantity of colour produced may either greatly exceed or fall short of what is expected. The quercitron bark thus prepared and proportioned, will generally yield as much colour as eight or ten times its weight of the weld plant, (reseda luteola, Linn.) and as much as about four times its weight of the chipped old fustic (morus tinctoria, Linn.): but the colouring matter of the bark, in its nature and properties, most clearly resembles that of the weld

plant; with this advantage, however, that it is capable *alone* of producing more cheaply, all, or very nearly all, the effects of every other yellow dyeing drug; and, moreover, some effects which are not attainable by any other means yet known.

The quercitron colouring matter may be readily extracted by water, even when it is only blood warm; but if the infusion be strained and left at rest, a small portion of resinous matter will separate and subside in the form of a whitish powder, capable of giving colours similar to those of the non-subsiding parts or particles. The clear infusion being evaporated, will afford an extract which, when completely dried, has, I think, commonly weighed as much as about one-twelfth of the bark from which it was obtained, and yields nearly as much colour as the whole of the bark. But it has been found very difficult to make this extract in any large quantity, so as to render it capable of given colours equal in beauty to those obtained *directly* from the bark itself; because, if the evaporation be rapidly performed, with a considerable degree of heat, the colour always becomes tarnished, probably by a combination of oxygene, producing effects similar or approaching to those of a slight combustion; and if the evaporation be conducted *slowly*, the colouring matter suffers greatly by another change, like that to which the decoction of weld is always liable, and by which the latter usually spoils by keeping, even in less than twenty-four hours.

There are several varieties of the quercus nigra, all containing a portion at least of the same species of colouring matter; but some of them, (particularly the quercus nigra digitata,* and the quercus nigra trifida,

* This seems to be Michaux's 2d variety, or "Chene quercitron feuilles sinueuses;" of which a cargo was imported from South

both of Marshall,) besides the yellow, contain a species of the *fauve*, or fawn colour, which tarnishes the yellow, and in calico-printing, occasions another bad effect, that

Carolina about the year 1785, by one of those who, about that time, infringed my rights; and its bad effects threw some discredit upon the true quercitron bark, by its being mistaken for the latter.

The oaks of America are, however, so numerous, and so apt to vary the forms of their leaves *by age*, that it is often difficult to distinguish one from the other, at least by their leaves. The younger Michaux, after stating the quercitron oak to be very common in the Northern States, and westward of the Alleghany mountains, though but rare in the lower parts of North and South Carolina, and Georgia, says, that the leaves of its lower branches affect a form different from the upper; "Celles ci (he observes,) sont plus profondement échancrées," and he adds, that the figure of this oak in the "*Histoire des Chenes*," &c. represents only the leaves of the *lower* branches, and of the *young* trees. He mentions, however, as a means of distinguishing this oak, that in all the other species "le petiole, les nervures, et les feuilles elles memes, sont d'un *vert* plus ou moins foncé," and that towards autumn this colour darkens, and becomes more or less red. But that the *same parts* in the "quercitron, sont dans le printems *jaunatres*, et comme pulverulentes," and that this *yellow* colour becomes the more marked as the winter approaches. He also mentions another peculiarity, which will point out the oak in question, when the leaves are fallen in winter; and this is the *bitter taste* of its bark, and the *yellow* colour which it gives to the saliva when chewed. He adds, indeed, (what he mentioned to me in 1802,) that he thought he had observed nearly similar properties in the bark of the quercus cinerea; but this last species may always be known from the other, because it grows only in the most dry arid spots of the Southern States, with lanceolated leaves, and seldom attains more than 18 feet in height, with 4 inches in diameter, whilst the quercus tinctoria or quercitron oak, often rises 80 feet above the ground, and its leaves have each *several lobes*. See Voyage a L'Ouest des Monts Alleghany, &c. par F. A. Michaux, M. D., &c.

By order of the French government, M. Michaux sent to France large quantities of the acorns of the quercitron oak, from which great numbers of plants have been produced in the nursery of *Trianon*, and in other places, with a view to the *bark* hereafter.

of staining those parts of the cotton or linen intended to be kept white, so as to make the bleaching of them afterwards very difficult. The barks of these last mentioned varieties have sometimes been mixed with that of the better sort, and in considerable quantities, (through the ignorance or the inattention of labourers employed in the collection,) so as to bring discredit upon this new and truly valuable dyeing drug: but there is reason to hope, that such improper mixtures will hereafter be avoided, in consequence of the very particular instructions which have been given for that purpose.

The decoction of quercitron bark appears to be of a yellowish brown colour, which is darkened by alkalies, and rendered lighter by acids; alum dissolved in it, separates but a small portion of the colouring matter, which subsides in the form of a deep yellow precipitate. Either the muriate, the nitro-muriate, or the murio-sulphate of tin, mixed with a decoction of the bark, produces an exceedingly beautiful lively yellow, and occasions a much more copious precipitation than the alum; probably because the calx of tin is heavier, and unites with the colouring matter in a much larger proportion.

Sulphate of iron, dissolved by a decoction of this bark, produces a copious dark olive precipitate, and the clear supernatant liquor remains of a light olive green.

Sulphate of copper in the like decoction, occasions a precipitation which is of a yellow inclining to the olive, and leaves the supernatant liquor of a yellowish green.

The effects of other bases and chemical agents upon the colouring matter of the bark, so far as they appear of any importance, will be discoverable from the following account of its various uses in dyeing and calico-printing.

Of the application of Quercitron Bark for the dyeing of Wool and Woollen Cloths, with an Aluminous Basis.

Wool, and the cloths or stuffs made from it, ought, in all cases, to be scoured before they are dyed, in order to separate a kind of grease with which the fibres are naturally covered. This is usually done by immersing the wool or cloth for about a quarter of an hour in a stale urine, diluted with three times as much water, and kept nearly of a scalding heat;* it is afterwards to be thoroughly rinced in clean water, and then dyed or impregnated with the proper mordants for dyeing, without any previous drying, that the colour may apply itself more equally.

Alumine, or the earth of alum, precipitated by clean potash, and repeatedly washed in pure water, being boiled with quercitron bark, readily united with its colouring matter, and produced a yellow inclining very much to the golden, or, as it is called, the *yolkey* hue; and wool boiled in this mixture for the space of half an hour, took a brownish yellow, which, however, seemed to have been but superficially applied; the earth of alum, in its undissolved state, not being able sufficiently to enter the pores of the wool, even when they are distended by boiling water.

The earth of alum, dissolved by the vegetable, the fossil, and the volatile, alkalies separately, as well in their mild as in their caustic states, was found to dye yellow colours of different shades, with the quercitron bark upon wool; but they were all inferior to those given by the same basis (alumine) when dissolved by acids.

The cheapest and most simple method of applying the quercitron colour upon wool, is that of boiling up

* See more on this subject at p. 64 of Vol. I.

the bark with its weight, or a third more than its weight, of sulphate of alumine, (common alum,) in a suitable portion of water for about ten minutes, and then dyeing therein the wool or cloth previously scoured, as before mentioned, taking care to give the higher colours first, and the paler straw colours afterwards. In this way yellows not wanted to be very full or bright may be dyed very expeditiously and cheaply; and they may afterwards be considerably raised and enlivened, by passing the wool or cloth, unrinced, a few times through hot water, into which a little clean powdered chalk has been previously stirred, in the proportion of about a pound or a pound and a half of chalk for each 100lbs. weight of wool or cloth. The bark, when used in dyeing, (being first ground,) should always be tied up in a linen bag, of a loose open texture, and suspended in the dyeing liquor by a cord, with which it may be dragged occasionally backwards and forwards through it, to extract and spread the colouring matter more equally.

But when the bark and alum are boiled together and united in this way, the colour does not afterwards fix itself either so readily, or so copiously upon the wool or cloth, as when the aluminous basis has been first applied separately in the common mode of preparation; and, therefore, this simple and cheap method of applying the quercitron colour is only suited for straws and pale yellows, especially as there is reason to suspect, that the adjective colours of every kind are not so durable when dyed with an aluminous basis in this way, as when they are dyed upon a like basis previously conveyed into and fixed in the substance which is to be dyed.

As often, therefore, as any thing more than a pale yellow is intended to be given from the quercitron bark and the aluminous basis upon wool or cloth, the latter

should be boiled in the common way, but *without either tartar or argol*, for the space of an hour, or an hour and a quarter, with about one-sixth or one-eighth of its weight of alum, dissolved in a suitable quantity of water, and then, *without being rinced*, it should be put into a dyeing vessel, with clean hot water, and about as many pounds of powdered bark, (tied up in a bag,) as there were used of alum to prepare the wool or cloth, which is then to be turned, as usual, by the winch through the boiling liquor, until the colour appears to have taken sufficiently; and then about one pound of clean powdered chalk for every hundred pounds of the wool or cloth, may be mixed with the dyeing liquor, and the operation continued eight or ten minutes longer, when the yellow will have become both higher and brighter by this addition of chalk.

The yellows given in this way from the quercitron bark are infinitely better, and considerably cheaper, than any which can be given from old fustic with an aluminous basis: indeed, they approach nearly to those given by weld with the common preparation of alum and tartar, and are in every respect as durable; though it must be confessed, that they have less of that lively greenish, or lemon hue, for which the weld yellows are particularly valued: this, however, may be readily and cheaply obtained, in the *utmost perfection*, from quercitron bark, by means which will hereafter be explained.

Wool or cloth, which has been first properly dyed blue in the common indigo vat, may be made to receive any of the various shades of green which are usually given in this way from weld, by boiling the blue wool or cloth, (after it has been well rinced,) in water, with about one-eighth of its weight of alum, as just directed for producing a yellow, and afterwards dyeing it unrinced, with about the same quantity of

bark, and a litle chalk, which should be added towards the end of th(process, as already described. Greens of less body ma' be dyed with smaller portions of bark and alum.

In the sam(way, cloth which has previously received the proper shade of Saxon blue, may be dyed of a beautiful Saxon geen: it will be proper, however, for this purpose, that the blue cloth should be first very well rinced to separate, as far as water will do it, the acid which may have been imbibed from the sulphate of indigo, and whch has a strong tendency to throw down and weaken te quercitron as well as the weld yellows. But as mere incing in water will separate only a small part of this acid from the cloth, (with which it combines in a cerain degree,) it will be proper to add about three pounds of chalk, with ten or twelve pounds of alum, for th(preparation liquor of 100lbs. weight of cloth, which is to be turned and boiled as usual for about an hour; and then, without changing the liquor, ten or twelvepounds of bark, powdered and tied up in a bag, may le put into it, and the dyeing continued, taking care requently to agitate the bag, in order that the colour of the bark may spread equally through the liquor. It wil be found, however, that the yellow will manifest itsef but slowly in this way, by reason of the sulphuric acil imbibed with the blue colour, joined to that of the aum in the preparation liquor, which the portion of chalk, before mentioned, will not have been sufficient to (vercome; and, therefore, when the dyeing with bark has continued about fifteen minutes, it will be proper t(add another pound of clean powdered chalk, stirring it well through the liquor, and to repeat this addition afterwards once, twice, and even three times, at intevals of six or eight minutes, if the colour does not risesufficiently without it. By these additions,

the quercitron yellow will manifest and apply itself abundantly and equally, so as to produce very beautiful greens, which, by varying the proportions of indigo, as well as of bark and alum, may be varied at pleasure. The chalk, in this case, does not merely answer the purpose of separating the acid left in the cloth by the sulphate of indigo and the alum, but, by uniting with this acid, it becomes a sulphate of lime, and fixes itself, in part at least, as a basis in the fibres of the cloth, where it helps to raise the colour, and also to render it a little more durable. At present the Saxon greens are commonly dyed with the old fustic, because the colour of this wood is not thrown down by acids so much as that of the bark and weld: and this difference enables the dyer, when he has extracted the fustic colour by previous boiling, to mix the sulphate of indigo therewith, and dye the cloth green by one operation, after it has been prepared as usual with alum and tartar. The process, however, which I have mentioned for doing this with bark, is full as cheap and as expeditious, and the green produced will be more beautiful, because the quercitron yellow is much more bright and clear than that of fustic.

At pages 62 and 63 of this volume, I have described a method of combining the Prussian blue and the quercitron yellow upon an aluminous basis, so as to produce a beautiful green colour, which I had flattered myself might be advantageously employed upon wool: further trials, however, have manifested so much difficulty in applying the colour equally, that I shall say no more of this combination at present.

Durable yellows may also be dyed upon wool, with either the muriate, the nitrate, or the acetite of alumine, but not with any superiority of colour which could compensate for the increased expense of these aluminous preparations.

Of the best methods of Dyeing upon Wool and Woollen Cloths with Quercitron Bark and the Tin Basis.

In Chapter IV. of Part II., I have mentioned the different effects of some of the preparations of tin in exalting the colour of the quercitron bark, as well as that of cochineal; and it will be remembered that, *for this purpose*, I found the muriate and the murio-sulphate of tin, preferable to any other of the preparations of that metal; I observed, however, that the former of these had an injurious action upon the fibres of wool and cloth, unless when sparingly and carefully employed, and was, therefore, less proper for general use than the solution of tin, made by a mixture of muriatic and sulphuric acids, as described at page 358 of my first volume; to which my readers will be now pleased to recur.

In order to dye 100lbs. weight of cloth or woollen stuffs of the highest and most beautiful orange yellow, only 10lbs. weight of quercitron bark, and the same weight of murio-sulphate of tin, will be required; the bark powdered and tied up in a bag, may be first put into the dyeing vessel with hot water, for the space of six or eight minutes, then the murio-sulphate of tin may be added, and the mixture well stirred for two or three minutes; after which the cloth may be put into the dyeing liquor and turned briskly for a few minutes: the colour applies itself in this way so equally to the cloth, and at the same time so quickly, that after the liquor begins to boil, the highest yellow may be produced in less than fifteen minutes, without any danger of its proving uneven. High shades of yellow, somewhat approaching to those dyed from bark, in the way just mentioned, are frequently given with the rhus cotinus, (commonly, though improperly, called young fustic,) and the dyers' spirit, or nitro-muriate of tin; but

he colour so given, is less beautiful and more fugitive, as well as more expensive, than that obtained from the bark, as just described.

When a very bright golden yellow, approaching less to the orange, is wanted, seven or eight pounds of murio-sulphate of tin, with about five pounds of alum, and ten pounds of bark, will suffice for 100lbs. of cloth; the bark being first boiled a few minutes, then the murio-sulphate of tin, with the alum added, and the cloth afterwards dyed, as just directed. Pure bright yellows, of less body, may be produced by employing smaller portions of bark, murio-sulphate of tin, and alum, in the same way: and, indeed, all the possible shades of *pure bright yellow* may be given, with the utmost ease and certainty, by only varying the proportions of these ingredients. But where it is expedient to give that *lively, delicate greenish tinge*, which, for certain purposes, is so much admired, and which the weld alone has been supposed capable of giving, white argol, or tartar, must be also employed with the bark, murio-sulphate of tin, and alum, in different proportions, according to the particular shade intended to be given. Thus, e. g. for a full bright yellow, delicately inclining to the greenish tinge, it will be proper to employ about eight pounds of bark, and six pounds of murio-sulphate of tin, with six pounds of alum, and four of clean white tartar, or cream of tartar; a little more alum and tartar will render the yellow more delicate, and give it more of the greenish tinge; and where this clean, lively, delicate greening tinge is wanted in the greatest possible perfection, it will be proper to use the bark, murio-sulphate of tin, alum, and tartar, all together in equal quantities. These last delicately-greenish lemon yellows, are but very seldom, if ever, wanted to be dyed of much fulness or body, and therefore ten pounds of bark, and the like quantities of

murio-sulphate of tin, alum, and tartar, will generally prove sufficient to dye three or four hundred pounds weight of cloth or woollen stuffs of the colours in question; for which purpose the bark is to be first boiled a few minutes in water only, then the other ingredients are to be added, and mixed in the liquor by stirring, and a few minutes boiling, and afterwards the cloth put into the liquor (first cooled a little) and turned briskly through it until the colour appears sufficiently raised. The pieces intended for the highest shades should be always dyed first, and those for weaker shades afterwards. When about two-thirds of the whole quantity of cloth has been dyed, it will generally be found, that the liquor, by continuing to extract colouring particles from the bark, has acquired an over-proportion of the latter, and wants a small addition of murio-sulphate of tin, alum, and tartar, (perhaps a pound of each,) to enable it to give the same delicately pale, though lively, greenish tinge, as at first: and indeed, a surer way of giving these very pale greenish shades with exquisite delicacy and beauty, is to boil the bark with a small proportion of water in a separate tin vessel for the space of six or eight minutes, then add the murio-sulphate of tin, alum, and tartar, and boil them all together for about fifteen minutes, and afterwards put a little of this yellow liquor into a dyeing vessel, previously supplied with water sufficiently heated, and the mixture being properly stirred, to begin dyeing the cloth as usual, adding farther supplies of the yellow liquor from the first vessel, by a little at a time, as fast as it may be wanted. In this way the palest and most delicate shades may always be dyed with ease and certainty; and those who have never seen the effects of this process, will hardly conceive the exquisite beauty and delicacy of these pale, but lively, greenish lemon yellows, which cert inly cost less than

any similar colours given, if such can be given, by any other means. Weld is unquestionably the only dyeing ware capable of producing effects similar to those of the bark in this respect, and at the average price it will prove nearly four times as costly, regard being had to the smaller portion of colour which it affords, besides the expense of long boiling, which the bark does not want, to extract its colour. Indeed, it may generally be computed, that the yellows dyed from quercitron bark, with murio-sulphate of tin and alum, do not cost, in dyeing materials, more than one penny for each pound of cloth, and that in time, labour, and fuel, they do not cost half as much as those usually given by other means. And this is also true of the more delicate shades given by bark, murio-sulphate of tin, alum, and *tartar;* for though this last ingredient be expensive, it is wanted only for the paler colours, which require smaller portions of dyeing materials, and, therefore, do not cost more than the highest shades given without it.

A greenish tinge may, indeed, be produced without tartar, by employing in its stead, a little verdigrise dissolved by vinegar along with the bark, &c., but I think it is neither so lasting nor so delicately clean and beautiful as that produced by the use of tartar. The sulphate of indigo will also produce this greenish tinge, if employed in a very small quantity with the bark, murio-sulphate of tin, and alum; but it has a tendency to fix itself so quickly upon the fibres of wool or cloth, that great care is necessary to hinder it from taking unequally, and the tinge produced by it is, moreover, somewhat liable to cast or fly, as the dyers say, in the finishing part; whilst the greenish tinge resulting from the use of tartar, as before directed, will leave the press perfectly clear and bright. Indeed, the colours obtained from quercitron bark by these means, are very durable;

they withstand even the action of strong mineral acids, and of boiling soap-suds, as well as exposure to air. This last, indeed, they are principally enabled to resist by the good effects of alum, and more especially of tartar. Since the highest yellows, which approach very nearly to the orange, and which are best dyed either with muriate, or murio-sulphate of tin, and bark, though they bear the action of soap and of acids in a wonderful degree, are liable, after some time, to lose a considerable part of their lustre, and acquire a brownish complection by exposure to the sun and air. This is also true of yellows dyed with nitro-muriate of tin (dyers' spirit) as a mordant, not only when employed with the bark, but with weld, and in a greater degree with fustic and other yellow vegetable colouring matters. In some of which this defect is not so well obviated by alum and tartar, as it is in the quercitron and weld yellows.

I must here remark, that tin, by whatever means dissolved, when applied as a basis for dyeing wool, renders the fibres a little harsh; so that they never run so far nor so easily in spinning as they would otherwise do, and the wool itself is apt to appear coarser; which is one reason for not dyeing scarlet in the fleece, and it may be one for not dyeing wool yellow with any of the solutions of tin as mordants, until it has been woven, or at least spun; though, I am persuaded, this defect is in a great degree obviated, by employing the murio-sulphate of tin, with a mixture of alum, or of alum and tartar, and combining these with the colouring particles of the bark, (in the ways which I have described,) *before* they are applied to the wool or cloth.

When yellows not quite so lively and beautiful can be made to answer, a much smaller proportion of the sulphate of tin will prove sufficient; five pounds thereof, for instance, may be boiled with ten pounds of bark,

ten pounds of alum, and two or three of tartar, and the cloth dyed as before directed. The decomposition and recomposition which result from a mixture of tartar with murio-sulphate of tin, will be readily conceived from what has been mentioned on this subject in the preceding chapter.

By using very small proportions of cochineal with the bark, murio-sulphate of tin, &c. the colour may be raised to a beautiful orange, and even to an aurora. Madder also employed in this way, raises the quercitron yellow, but the effect is less beautiful than with cochineal; and this is also the case when madder is employed with weld.

At pages 283 and 284 of my former volume, I have made some mention of the means of dyeing woollen cloth topically or partially; and since that time I have found, that by mixing a strong decoction of the bark, with a suitable proportion of murio-sulphate of tin, &c. and thickening the mixture, as for the pro-substantive topical yellows, hereafter to be described, for calico-printing, then applying the mixture by a pencil to the woollen cloth, covering the pencilled parts with paper, so as to prevent the moist colour from spotting the other parts, afterwards folding up the cloth, and tying it in a bag made of that kind of oiled linen, which is used for bathing caps, so as to exclude water, and then keeping it immersed in boiling water for a quarter of an hour, a full and beautiful yellow was fixed upon the parts which had been pencilled, without any farther running or spreading of the colour. The same mixture pencilled upon cloth which had been previously dyed Saxon blue, produced a beautiful green where it had been pencilled. Diluted sulphate of indigo pencilled upon scarlet cloth, and treated in the same way, produced a full black; and it seems to be easy, by employ-

ing proper mixtures in this way, to produce all the varieties of colours topically upon woollen stuffs: as far as I can judge, the oiled linen, which, I believe, was never before employed for this purpose, is much more suitable to it than any means now in use.

The most beautiful Saxon greens may be produced very cheaply and expeditiously by combining the lively yellow which results from quercitron bark, murio-sulphate of tin, and alum, with the blue afforded by indigo when dissolved in sulphuric acid, as for dying the Saxon blue.

To produce this combination most advantageously, the dyer, for a full bodied green, should put into the dyeing vessel after the rate of six or eight pounds of powdered bark, (in a bag,) for every 100lbs. weight of cloth, with only a small proportion of water, as soon as it begins to grow warm; and when it begins to boil, he should add about six pounds of murio-sulphate of tin, (with the usual precautions,) and a few minutes after, about four pounds of alum; these having boiled together five or six minutes, cold water should be added, and the fire diminished so as to bring the heat of the liquor nearly down to what the hand is able to bear; and immediately after this, as much sulphate of indigo is to be added as will suffice to produce the shade of green intended to be dyed, taking care to mix it thoroughly with the dyeing liquor by stirring, &c.; and this being done, the cloth previously scoured and moistened, should be expeditiously put into the liquor, and turned very briskly through it for a quarter of an hour, in order that the colour may apply itself equally to every part, which it will certainly do in this way with proper care. By these means, very full, even and beautiful greens, may generally be dyed in half an hour; and during this space, it is best to keep the liquor at rather

less than a boiling heat. Murio-sulphate of tin, is infinitely preferable, for this use, to the dyers' spirit; because the latter consists chiefly of nitric acid, which by its highly-injurious action upon indigo, would render that part of the green colour very fugitive, as I have found by repeated trials. But no such effect can result from the murio-sulphate of tin; since the muriatic acid has no action upon indigo, and the sulphuric is that very acid which alone is proper to dissolve it for this use.

Respecting the beauty of the colour thus produced, those who are acquainted with the unequalled lustre and brightness of the quercitron yellows, dyed with the tin basis, must necessarily conclude, that the greens composed therewith will prove infinitely superior to any which can result from the dull muddy yellow of old fustic: and in point of expense, it is certain that the bark, murio-sulphate of tin, and alum, necessary to dye a given quantity of cloth in this way, will cost less than the much greater quantity (six or eight times more) of fustic, with the alum necessary for dyeing it in the common way; the sulphate of indigo being the same in both cases. But in dyeing with the bark, the vessel is only to be filled and heated once; and the cloth, without any previous preparation, may be completely dyed in half an hour; whilst in the common way of producing Saxon greens, the copper is to be twice filled; and to this must be joined the fuel and labour of an hour and an half's boiling and turning the cloth, in the course of preparation, besides nearly as much boiling in another vessel to extract the colour of the fustic, and after all, the dyeing process remains to be performed; which will be equal in time and trouble to the whole of the process for producing a Saxon green with the bark; so that this colour obtained from bark will not only prove superior

in beauty, but in cheapness, to that dyed as usual with old fustic.

M. Dambournay, in the supplement to his "Recueil de procedés et experiences sur les teintures solides," &c. mentions various experiments made by him with the quercitron bark, from which he concludes, that in order to produce the good effects which I had previously described as resulting from its use in dyeing woollen cloths, these should be first impregnated with a tin basis, and then dyed in the manner which I had directed. In this way, says he, I obtained full shades of that beautiful yellow, a little greenish, but very durable, ("de cé beau jaune un peu verdatre et tres solide,") which is is so well suited to produce a *fine green*, either by the indigo vat, or by the composition for Saxon blue, i. e. sulphate of indigo. And having applied this latter by the common mode of dyeing, to cloth which had previously received the quercitron yellow, and also to cloth dyed yellow with the Lombardy poplar, (which, in other respects, he greatly commends,) he found that the former which had received the bark yellow, took a fine dragon green, ("un beau vert dragon,") and the latter nothing better than a greenish olive. It is true that M. Dambournay computes the expense of dyeing with the quercitron bark, as greatly surpassing that of dyeing with the Lombardy poplar. But his computation was founded on very erroneous suppositions, joined to the circumstance of his calculating the muriatic acid to cost near two shillings and sixpence sterling the pound weight, which is more than six times its real cost; though this may, probably, have been nearly the price which it bore in France, whilst the *gabelle* subsisted there.

The nitro-muriate of tin, (dyers' spirit,) though it produces good yellows with quercitron bark, produces

them in a much weaker degree than the murio-sulphate of that metal; which is really the cheapest, and most efficacious, of all the solutions or preparations of tin, for dyeing the quercitron as well as the cochineal colours.

The sulphuric acid by itself dissolves, or rather calcines, a large portion of tin, if allowed to act upon it for any considerable time; and this solution, joined to the bark, with alum and tartar, produces bright strong yellows on cloth, though I think they appear less soft and beautiful, than those dyed either with the muriate, or murio-sulphate of tin. This metal dissolved, or rather calcined, by a mixture of the nitric and sulphuric acids, is still less suitable for dyeing with the bark.

Tin dissolved by muriatic acid, to which one-third of its weight of clean white tartar had been previously added, produced a very bright and delicate yellow with the bark, upon cloth, and this, by longer boiling, was raised to a full and beautiful orange. Tin dissolved in strong nitric acid, (double aqua fortis,) with an addition of one third of its weight of tartar, also produced a very good yellow, though somewhat inferior to the last.

Upon putting tartar, with a portion of tin, into a glass vessel with strong colourless sulphuric acid, the latter, or rather its oxygenous part by combining with the inflammable part of the tartar, immediately rendered the mixture as black as ink; and the solution of tin produced by it, was found of but very little use as a mordant for dyeing with the bark.

The oxide of tin, produced by the action of the nitric acid upon that metal, contains a large portion of oxygene; and yet it raises the quercitron yellow: but when this oxide is dissolved in muriatic acid, it produces only a very feeble lifeless yellow with bark; though tin not previously oxygenated will, when dissolved by the same (muriatic) acid, act most powerfully in exalting the quer-

citron yellow: which seems to prove, that this defect of colour does not result from the presence of oxygene alone, but from its combination with muriatic acid. A similar effect was also produced by employing tin calcined by sulphuric acid, and then dissolved in the muriatic, as a mordant with the bark.

Cloth boiled in water with the muriate of tin and tartar, has sometimes been made yellow, and sometimes of a chesnut brown, *only* from the action of this mordant, unassisted by any colouring drug. These discolorations seem to depend upon the particular state of the cloth, as being more or less freed, either from the natural swint of the wool, or the grease commonly applied to it for particular purposes. Discolorations of this kind are not easily removed; they withstand the action of sun and air for a considerable time, and if cloth so discoloured be dyed with either bark or with cochineal, the colour will appear tarnished; for which reason the application of muriate of tin, with tartar *only*, as a mordant, ought to be avoided, unless the dyer be very certain that the cloth has previously been perfectly well scoured.

A few lumps of the dry oxide of tin, mentioned at pages 159 and 160 of the former volume, having been finely powdered and mixed with a suitable quantity of decoction of quercitron bark, the mixture was found capable of dyeing a very full and bright yellow upon woollen cloth. The colour, however, being exposed to the action of the sun and air, very soon acquired a brownish complexion. Some of the same oxide of tin reduced to powder, having been washed in warm water, to remove the adhering acid, as far as water could remove it, was found to be still capable of combining with the colouring matter of the bark, so as to dye cloth yellow; especially when the oxide had been previously suffered

to remain mixed with the decoction of bark, for some hours, in a warm situation. Cotton also took a yellow colour by dyeing in this mixture; but it was easily removed by washing with soap, and therefore was, I think, only applied superficially.

I have but little to offer respecting the use of copper, or rather of the oxides and solutions of that metal *alone*, as mordants or bases for dyeing with quercitron bark on wool or cloth. Their general effect is to raise and fix the quercitron yellow; but at the same time to give it a greenish or rather an olive tint. Wool dyed with a tenth of its weight of bark, and half as much sulphate of copper, received an agreeable colour, between the yellow and the olive. The bark, with muriate of copper, seemed to impart but little colour to wool for some time; but a little chalk being added, a full yellowish olive was produced. This also proved to be the case, when nitrate of copper was employed with the bark, until chalk had been added; and then the wool speedily imbibed a yellow, delicately inclining to the olive hue. Verdigrise with the bark produced a yellowish olive on wool; which, by the addition of chalk, was brightened, and made to approach nearer to the yellow. These colours appeared to be sufficiently lasting.

Drab colours of various shades may be most expeditiously and cheaply dyed by the quercitron bark and an iron basis. For this purpose the bark may be boiled a few minutes in a copper vessel, with one-third, or one-fourth of its weight of sulphate of iron, (copperas,) according to the shade required, and the liquor having been well mixed, and a little cooled, the cloth may be dyed therein as usual; but without any other preparation than that of scouring and moistening. To sadden and darken the colour still farther, a little sumach, (rhus coriaria,) may be added with the bark; and on the other hand, the colour may be inclined to the olive and yel-

low, by diminishing the quantity of sulphate of iron, and employing with it a little alum and chalk; or (which is better) a little sulphate of copper, with or without a small proportion of chalk. Or the cloth may be first turned a few times through a vessel, with boiling bark liquor, then taken out, and turned briskly through a vessel with hot water, in which a suitable proportion of sulphate of iron has been dissolved, with or without either alum and chalk, or sulphate of copper and chalk, as the particular colour intended to be given may require. In either way the colours will prove lasting, and the expense very small; four or five pounds of bark being generally sufficient to die one hundred pounds weight of cloth, of the colours in question. Cloth prepared by previous boiling, with one-twentieth of its weight of sulphate of iron, and one-fourth of that quantity of chalk, and then dyed in bark liquor, became of a strong durable chocolate colour; but in this way great care is necessary to render the colour even.

Cloth prepared by boiling with a twentieth of its weight of sulphate of iron, half as much sea-salt, and one-fourth of that quantity of chalk, and then dyed with bark, received a very lasting dark brown colour.

Cloth dyed with quercitron bark, sulphate of iron, and sulphate of manganese, in small proportions, became of a light, but pleasing, drab colour; which, by the addition of a little chalk, was afterwards changed to the cinnamon.

Cloth prepared with nitro-muriate of gold, and dyed with bark, became of a delicate olive yellow. The solutions of bismuth, zinc, antimony, silver, mercury, lead, and platina, by different acids, produced various shades of brown, yellowish brown, brownish yellow, cinnamon, drab, and olive colours; of which it is not expedient to give my readers a particular description, because they

either may be all more cheaply obtained by other mordants, or are not likely to be brought into use.

Cloth boiled in water, with one-twentieth of its weight of sulphate of lime, and dyed with bark, received a strong nankeen colour. Nitrate of lime in this way, produced a nutmeg brown; and the muriate of lime produced a very full and lasting drab colour, which, in some respects, may be preferable to the drabs given by an iron basis, and especially as being less likely than the latter to injure the texture of the cloth.

Of the Properties and Uses of Quercitron Bark in dyeing upon Silk.

All the different shades of yellow, commonly dyed upon silk from weld, may be obtained with equal facility and beauty, and more cheaply, by employing the bark in its stead, after the rate of from one or two pounds for every twelve pounds of silk, according to the particular shade of colour wanted. For this purpose the bark, powdered and tied up in a bag, should be put into the dyeing vessel whilst the water is cold, and as soon as it becomes a little more than blood-warm, the silk, previously alumed, should also be put in and dyed as usual; and where the higher yellows are wanted, a little chalk or pearl-ashes may be added towards the end of the operation, as mentioned for the dyeing of wool.

Where shades of yellow, more lively than any which can be given either by weld or bark with the aluminous basis only, are wanted, it will be advantageous to employ a little of the murio-sulphate of tin; and but a little of it, because the calx of tin, unless sparingly used, always diminishes the glossiness of silk.

To produce the shades in question, it will be sufficient to boil, after the rate of four pounds of bark with

three pounds of alum and two pounds of murio-sulphate of tin, with a suitable quantity of water, for ten or fifteen minutes, and the heat of the liquor being afterwards reduced so that the hand can bear it, the silk is to be put in and dyed as usual, until it has acquired the proper shade, (which it will do speedily,) taking care, however, to agitate the liquor constantly, that the colouring matter, which would otherwise subside in a considerable degree, may be kept equally dispersed through the liquor. By adding suitable proportions of sulphate of indigo to this yellow liquor, and keeping it well stirred, various and beautiful shades of Saxon green may be dyed in the same way very equally and cheaply. The shades intended to incline most to the yellow should be first dyed, and afterwards, by adding more sulphate of indigo, those partaking more of the blue may be readily produced; and, indeed, nothing can be more commodious or certain than this way of dyeing the most beautiful Saxon greens upon silk.

By dissolving different proportions of copperas, or copperas and alum, in the warm decoction of bark, silk may, in the same way, be dyed of all the different shades of olive and drab colours; and other varieties may be produced with the bark generally, by employing the same means which are used to produce the like variations with weld.

Of the Application of Quercitron Bark to the Fibres of Linen or Cotton, either woven or spun, by general Dyeing.

I here use the term *general* dyeing as opposed to that *partial* or *topical* application of colours on which calico-printing chiefly depends. At page 67 of my former volume, I have endeavoured to explain the causes which render adjective colours less durable on linen and

cotton than they are on wool or silk, so far, at least, as these causes depend on differences in the structure and chemical properties of the substances in question; but whether my explanation be well founded or not, this at least is certain, that the attraction between the aluminous basis and the fibres of linen and cotton, is much weaker than that which subsists between the same basis and the fibres of wool or of silk; and this want of a sufficient attraction or affinity has made it necessary to employ extraordinary means for precipitating the alumine more copiously, and fixing it more firmly, than it otherwise would be precipitated and fixed upon the fibres of linen or cotton, in order to enable them to receive permanent adjective colours by dyeing. The principal of these means are certain oily and animal matters joined to some vegetable astringents, particularly galls; all of which, I mean the former as well as the latter, evidently possess a strong attraction for alumine, and when united to linen or cotton, produce very beneficial effects, as is manifestly seen by the process for dyeing the Adrianople or Turkey red, concerning which Mr. Henry, M. Berthollet, and M. Chaptal, have published several very ingenious as well as highly interesting observations; at present, however, I shall only notice these extraordinary means, so far as they seem likely to improve the beauty and durability of the colours capable of being communicated to linen or cotton from quercitron bark.

The fibres of linen or cotton, when spun or woven, are prepared for the dyer by being first boiled in water with a suitable portion of potash, (which for linen should be made caustic, in order that it may act more strongly upon the oily and resinous matters abounding in flax,) and afterwards bleached by exposure upon the grass to sun and air. But as this operation commonly leaves a portion of earthy matter in the linen or cotton, which,

by being unequally distributed, would render any colour given by dyeing unequal; the cotton or linen ought to be soaked or steeped in water, soured by sulphuric acid, to dissolve and remove this earthy matter, taking care afterwards to wash or rince off the acid, lest, being concentrated in the cloth or yarn when drying, it should injure the texture.

The method prescribed by the French regulations, and adopted in most European countries, for dyeing yellow upon linen or cotton from the weld plant is, by soaking the cloth or yarn in a liquor made by dissolving one-fourth of its weight of alum in as much water as is necessary for that purpose; to which it will be highly advantageous to add, after the rate of one pound of clean potash or ten ounces of chalk, for every six or seven pounds of alum,* to neutralize the excess of acid contained in the alum, and promote a separation of its earthy basis. The cloth or yarn having been thus soaked, is taken out of the alum liquor, and well dried; and being afterwards rinced, it is to be dyed in weld liquor made by boiling about one pound and a quarter of the plant for each pound of cloth or yarn; which, after having received a sufficient body of colour, is to be taken out of the dyeing liquor, and soaked for an hour and more, in a solution of sulphate of copper, (blue vitriol,) containing after the rate of three or four ounces of the latter for each pound of cloth or yarn; it is then to be removed, and, without being washed, put into a boiling solution of hard soap, containing in like manner three or four

* Haussman says, that when English alum is dissolved in five times its weight of water, and one-eighth of its weight of chalk is added to saturate the excess of acid, a solution will be produced, which does not crystallize in summer, and but little in winter; though without chalk it requires sixteen times as much water as of alum to make a permanent solution.

ounces of soap for each pound of cloth or yarn, in which it is to be well stirred and boiled for about three quarters of an hour or more, then washed and dryed. I have found, by repeated trials, that this mode of precipitating the calx of copper upon the yellow previously dyed from weld with an aluminous basis, renders the colour more durable, but, at the same time, gives it a darker complexion. And I have found similar effects where bark was used instead of weld; the colour dyed with the bark in this way having proved, in every respect, as good as that obtained from weld: but I am convinced, that whether the colouring matter be taken from the former or the latter of these vegetables, the yellow dyed in this way never is either so beautiful or so lasting as that partially given by calico-printers from the same vegetables, and which the dyers might readily give with equal perfection, by only employing the acetite of alumine, or aluminous mordant, described at pages 266, 267, and 268 of my first volume; and this more cheaply as well as more expeditiously than that produced by following the French regulations; considering the expense of so much blue vitriol and soap as they require, and which may be rendered unnecessary by adopting the calico-printers' aluminous mordant.

The best method of applying the aluminous mordant for general dyeing with quercitron bark (which I most earnestly recommended whenever bright and durable yellows are wanted,) is as follows, *viz.*

Take a sufficient quantity of the acetite of alumine, which for this purpose may be made by dissolving after the rate of *only* one pound of sugar of lead and three pounds of alum, as at the pages just quoted,* excepting

* See also the cheaper means of preparing an acetite of alumine, mentioned in the note to p. 271 of Vol. I.

only that it need not be thickened, and mix this liquor with an equal quantity of warm water, then let the linen or cotton (properly cleansed, as before mentioned) be thoroughly wetted and soaked in the mixture, which ought to be about blood-warm, for the space of two hours, then taken out and moderately squeezed or pressed over a proper vessel to collect what might otherwise drop or run off, and prevent an unnecessary waste of the aluminous liquor; and this being done, let the linen or cotton be well dried in a stove heat, where it can be conveniently applied, and then soaked again in the aluminous mordant, and again pressed or squeezed and dried as before; after which, without having been rinced, let it be thoroughly wetted in as much, and only as much, lime water as will conveniently suffice for that purpose, and afterwards dried; and where a very full, bright and durable yellow is wanted, it may be well to soak the linen or cotton a third time in the diluted aluminous mordant, and after drying, wet it a second time with lime water, and dry it again: but in either case, the linen or cotton, after its last dyeing, should be well rinced in clean water, in order to separate any loose or unfixed particles of the mordant or basis, which otherwise might do harm in the dyeing vessel. The lime-water employed in this way, answers the purpose of producing a more copious deposition of the alumine in the fibres of the linen or cotton, and it moreover superadds a portion of calcareous to the aluminous basis; an effect which is not without considerable utility.

I have found, that when the aluminous liquor has been employed at a scalding heat, the colour afterwards produced was not so good as that which results from liquor only made blood-warm; the pores of linen and cotton being so open as not to require any distension by a greater degree of heat.

The cotton or linen being prepared and rinced, as before mentioned, a small fire is to be lighted under the dyeing pan or vessel, previously supplied with the usual quantity of water, and the powdered quercitron bark tied up in a bag, after the rate of from twelve to eighteen pounds for every hundred pounds weight of linen or cotton, where full-bodied yellows are wanted, is to be put in, whilst the water is cold, and immediately after it, the linen or cotton is also to be put in, upon sticks, if it be thread or yarn, or, if piece-work, on the winch, agitating or turning it, in either case, as usual, for the space of an hour, or an hour and a half, during which the water should gradually become warm, but not warmer than the hand can bear. When this time has elapsed, the fire may be increased, and the dyeing liquor brought to a scalding, and thence to a boiling heat; in which it will be sufficient to let the cotton or linen remain a few minutes only, when a bright lively yellow is wanted, because longer boiling always gives the yellow a brownish cast, whatever vegetable may be employed in dyeing it. The linen or cotton having thus acquired sufficient colour, is to be taken out, rinced, and dried as usual.

When the colour of quercitron bark is slowly raised in this manner by a very moderate heat, the colouring particles seem to adjust themselves more accurately, and unite more intimately, to those of the basis, and thereby to produce a colour more fixed and durable than it is when they are hastily accumulated by a boiling heat, and, perhaps, chiefly upon the surface of the substance dyed, and of the basis combined therewith.

All the different shades of yellow may in this way be dyed from quercitron bark: if it be used sparingly, with a very moderate heat, and the operation continued only for about half an hour, a pale, though lively yellow will

result; if used more copiously, and the operation continued somewhat longer, a fuller colour will be produced; and this may be raised higher and higher according as the heat and proportion of bark are increased and the dyeing operation prolonged, so as, indeed, to produce a very dark brownish yellow, if the liquor be made to boil for half an hour.*

Pieces of cotton having been prepared with the printer's aluminous mordant and lime water, as already described, were dyed one with bark and another with weld, and being taken out of the dyeing liquors, a bit was cut off from each, and the remainder put back again into its liquor, in which a small quantity of sulphate of copper had, in the mean time, been dissolved, (after the rate of one ounce to five pounds of cotton,) and the liquors being nearly of a scalding heat; in about ten minutes the pieces were again taken out and found to have acquired a brownish complexion; but, being exposed to the sun and air along with the bits which had been cut off before the sulphate of copper was added to the dyeing liquors, the brownish complexion of the former soon disappeared, and their remaining colour, at the end of four weeks, proved to be rather better than that of the bits dyed without the sulphate of copper. It seems, therefore, probable, that a sparing use of the latter in this way, may contribute something at least to the durability, if not to the beauty, of yellows dyed upon linen or cotton, *after* the application of acetite of alumine and of lime, as before directed.

* M. Chaptal appears to think that lime may be usefully employed to extract, raise, and fix the colour of quercitron bark. He says, that having added quick lime to a decoction of this bark it produced " un magma d'une *magnifique* couleur jaune, qui jouit d'une assez forte fixite et dont on peut tirer une grande parti dans la teinture." See his Chimie appliquée aux arts, tom. iv. p. 460.

When the aluminous mordant is employed without any addition of water, it may be sufficient to soak the cotton therein *once* only, and after dyeing to immerse it *once* in lime water, then dry, rince, and dye it, as before mentioned. I think, however, that better effects result from the application of a more diluted mordant, *at two different times;* and, indeed, I have found, that by immersing the cotton *a great number of times* alternately in the diluted aluminous mordant and in lime water, and drying it after each immersion, the colour always acquired still more body and durability.

At page 275 of my former volume, I have remarked, that by the East Indian method of calico printing, the want of acetite of alumine is supplied by impregnating cotton with the astringent matter of yellow myrobalans, and with certain oily and animal substances, which enable the cotton, when a solution of alum is afterwards applied to it, to decompose and imbibe a larger portion of alumine: and this practice may be imitated in dyeing the quercitron yellow upon cotton, with so much advantage as to render the acetite of alumine in a great degree unnecessary, at least where the yellow is not required to be very clear and bright.

Instead of myrobalans, (which are, however, to be found here,) the Aleppo galls may be employed, choosing always the whitest for this use, because the browner might stain the cotton, so as to render it incapable afterwards of receiving a bright clear yellow; and, perhaps, in this respect, the roots of at least two or three species of North American sumach, particularly the rhus glabra, Linn. might be preferable even to the whitest galls, by communicating less stain, and producing equally good effects, as I have found them to do in repeated trials.

The best method of employing galls for this purpose is, I believe, to boil after the rate of one pound of them, coarsely powdered, with half a pound of barilla, for the space of one hour, in two or three gallons of soft water, and then straining off the decoction to macerate the cotton an hour or two therein; barilla, or rather the soda which it contains, enables the water to extract the astringent matter of the galls much more copiously than it otherwise could do; and being itself imbibed by the cotton, it also occasions a more plentiful deposition of alumine, when the cotton is afterwards put into a solution of alum, which, for this use, may be made by dissolving eight pounds of alum and one pound of chalk in six gallons of water. In this calcareous solution of alum, the cotton, after being taken out of the decoction of galls and dried, is to be soaked for two hours, then taken out and dried; then soaked a few minutes in lime water, and having been again dried, it is to be immersed a second time in the calcareous solution of alum; after which, being again dried and well rinced, the cotton is to be dyed slowly with the quercitron bark, as before directed. In this way very full-bodied and lasting yellows may be obtained, which will bear repeated washings with soap, as well as exposure to sun and air, and the action of strong vinegar.

By dissolving after the rate of one pound of hard white soap, and half a pound of barilla, in three gallons of water, and macerating the cotton therein, as directed to be done with the decoction of galls and sumach, then drying and immersing it in a calcareous solution of alum, and afterwards proceeding, as just directed to be done after such immersion, I obtained a colour (with the bark) nearly as durable as when the decoction of galls had been used, and with the advantage of its not being thereby *darkened.*

A pound of the yolks and whites of eggs, having been first beat up with an equal quantity of brown sugar, and then with two gallons of water, and cotton having been soaked therein, instead of the solution of soap and barilla, then dried and immersed in the calcareous solution of alum; dried again and immersed in lime water, and then in the solution of alum, and afterwards rinced, and dyed with bark, as already described, it received a very full and lasting, though darkish yellow colour. The animal mucilages in general, and some of the vegetable, being dissolved in water and applied to cotton in the same way as the yolks and whites of eggs, just mentioned, produce the like good effects, and more especially the animal glue; which appears to unite both with the cotton and the aluminous basis when used in this way.

A considerable time has now elapsed since I was induced to try the effects of alumine combined with other acids, besides the sulphuric and acetous, and also with potash, soda, and ammonia, both in their mild and their caustic states, as a basis or mordant for the quercitron colouring matter. To separate alumine from the sulphuric acid with which it forms common alum, this last compound may be dissolved in about eight times its weight of clean boiling water, and mixed with a filtered lixivium of clean potash, which should be added to the solution of alum gradually, until it no longer makes the liquor turbid, or occasions any further precipitation of alumine. The whole of the mixture may then be put into a canvass strainer to separate the fluid part, and this having been done, boiling water may be poured repeatedly upon the remaining moist alumine, and suffered to run through the strainer until the saline part of the mixture shall have been washed away, as far as it is capable of being washed away by water; the alumine

being then taken out and dried, will generally be found to weigh about one-fifth part of the weight of the alum employed to produce it: when thoroughly dried, the alumine contracts or shrinks greatly, and becomes at length so hard, that neither strong sulphuric or nitric acids can dissolve it, except with great difficulty and very slowly; and for this reason it ought always to be employed in a moist state, when intended to be again dissolved by any acid or alkaline menstruum. Perhaps the great disposition of this earth to contract or shrink by drying, may be one reason why it is generally most advantageous to convey and fix the particles thereof as a basis in the pores of linen or cotton, *first* separately, and afterwards, when they have shrunk by drying, to superadd the adjective colouring matter, which may then find more space, and combine with the alumine in greater proportion than it could do when both, previously united, were applied together, whilst the particles of alumine were enlarged by moisture.*

If moist alumine, obtained in the manner just described, be dissolved in either the nitric or muriatic acids, it will, by evaporation, afford crystals; and those obtained with the nitric acid, by attracting moisture from the atmosphere, will prove deliquescent, unless kept in a vessel closely stopped. M. Berthollet found, that in these cases, the crystals depended on a remnant of sulphuric acid, which always adheres to alumine, when separated in the way just described; and that, by

* Another cause seems to be this, that when the colouring matter and the basis are first separately united, their affinities are exclusively exerted upon, and satisfied with, each other; and when they are afterwards applied to the stuff intended to be dyed, they have less attraction for it, and the size of their combined particles being increased by this union, they do not precipitate so far or so copiously.

afterwards digesting it for some time in a solution of potash, or of ammonia, this adhering sulphuric acid might be decomposed; and that the alumine being then dissolved, either in the nitric or the muriatic acid, no crystals were produced. It must, however, be remarked, that the alumine mentioned to have been employed in the succeeding trials, was obtained in the way first described, and, therefore, was not completely divested of sulphuric acid.

Having boiled a suitable portion of moist alumine with a decoction of quercitron bark during the space of half an hour, I attempted to dye both wool and cotton therewith, in order to see whether the undissolved particles of alumine, so united to the colouring matter of the bark, would become the basis of a lasting colour. I found, however, by repeated trials, that cotton in this way could only be made to imbibe a pale yellow, which, probably, adhered to the surface only of its fibres, because it was nearly destroyed by a single week's exposure to the sun and air. Wool, however, in this way received a brownish yellow, of sufficient body and considerable durability.

Ammonia, or volatile alkali, whether mild or caustic, appears to dissolve alumine so very sparingly, that hitherto I have found no considerable benefit from any solution of this kind as a mordant. Nor have I succeeded much better with either the carbonated (mild) potash, or that of soda, their action not being considerable upon the earth of alum. But if this earth, obtained by precipitation and washing, as before mentioned, be digested whilst moist with a strong lixivium either of potash or of soda, in its pure or caustic state, in a matrass placed on a sand heat, nearly approaching that of boiling water, it dissolves very copiously, and may afterwards, by evaporation, be made to crystallize. The

celebrated Macquer appears to have believed, that very beneficial effects might be obtained in dyeing by these combinations, and more especially when used as mordants for the madder red on cotton. It seems evident, however, that he was greatly mistaken respecting the true nature of those operations, upon which this belief was founded; and that in the process for Turkey reds, where he supposed the durability of colour to result principally from a combination of this kind, no solution of aluminous earth by any alkaline menstruum could have taken place; and though Mr. Haussman appears also to have formed considerable expectations of advantage from the application of these solutions of alumine by potash or soda, I have been led, by the results of many trials, to concur in opinion with M. Berthollet, that but little good is to be expected from them, unless it be under the circumstances which I shall presently explain, because the alkaline menstruum evidently has too much affinity to the particles of alumine to allow of their being deposited and fixed in the substance to be dyed so copiously as is necessary; and I have repeatedly found, that after having soaked cotton a sufficient time in the diluted solution of alumine by either potash or soda, the basis was almost wholly carried off, or removed by only rincing the cotton in water to fit it for being dyed, and that only very feeble colours could be raised upon what remained of the alumine as a basis. This was more especially the case where the solution of alumine had been made by potash, which, by attracting moisture from the atmosphere, rendered it difficult to dry the cotton sufficiently when impregnated therewith, at least without artificial heat. These defects were, however, removed, and a *very excellent durable yellow* produced, by putting the cotton, which had been *first* soaked in a diluted solution of alumine by potash, into

water which had dissolved as much common alum as it could retain, whilst blood-warm, macerating and turning it therein for the space of half an hour, (during which the potash and sulphuric acid combining, each precipitates the alumine of the other,) then drying the cotton, and afterwards immersing it in lime-water; then drying again, rincing and dyeing it with the bark, as before directed. The yellow given in this way faded but very little by two months exposure to sun and air in the midst of the summer; nor was it sensibly weakened by the action of strong French vinegar, or of the oxygenated muriatic acid. The solution of alumine by soda produced equally good effects in this way.

Nitrate of alumine (made by saturating the nitric acid with moist alumine, as before mentioned,) being dissolved in eight times its weight of water, and used instead of the solution of common alum, last mentioned, produced a yellow rather better and more durable, even than the last. Cotton, which had received no impregnation, being macerated in a like solution of the nitrate of alumine, then dried, immersed in lime-water, rinced, and dyed with the bark, received a yellow considerably better than I could obtain with a solution of common alum in the same way.

Muriate of alumine generally produced with the bark, effects as good, but not materially better, than those resulting from common alum used in the same ways.

In dyeing any of the yellows before mentioned with bark, the colour may be raised to an orange by employing a suitable proportion of madder along with the bark.

It can hardly be necessary for me to mention, that linen or cotton, either spun or wove, when previously dyed blue of a suitable shade in the usual ways, will be rendered green by superadding the quercitron yellow in the ways, and by the means, already directed for

dyeing this yellow upon linens and cottons, not previously made blue, taking care to proportion the quantum or body of each of the component blue and yellow colours to the particular shade of green which they are intended to compose or produce.

Linen and cotton soaked four hours in a mordant made by dissolving lime in muriatic acid, and mixing the solution with six times its weight of water, afterwards dried, rinced, and dyed with quercitron bark, took a full drab colour, which resisted the action of sun and air for a considerable time: but neither the sulphate nor the nitrate of lime employed in this way with the bark, gave any thing more than buff or slight nankeen colours, of little durability.

Magnesia dissolved by the sulphuric, the nitric, muriatic, and acetous acids, and used in this way as a mordant, produced with bark, upon linen and cotton, weak drab, cinnamon, and nankeen colours, which, however, proved too fugitive to be of any use.

Cotton, soaked in a diluted solution of flints, made as formerly mentioned, and afterwards rinced and dyed with the bark, became of a nankeen colour somewhat lasting.

Among the metallic bases, that of tin might be expected to produce beneficial effects by *general dyeing* upon linen and cotton with the quercitron bark; but hitherto my experiments therewith, though they have been very numerous and greatly diversified, afford no successful results: for though different solutions of tin, (particularly the nitro-muriatic and the murio-sulphuric,) when diluted and applied as mordants to linen and cotton, enabled these substances afterwards to imbibe yellows exceeding all others in brightness, lustre, and beauty; and though these yellows are capable of resisting the action of boiling soap-suds, as well as of strong

acids, not excepting the oxygenated muriatic acid, yet they decay very speedily when exposed to the sun and air, so as even to suffer more in a single week than the quercitron yellows dyed upon an aluminous basis commonly suffer in a month. The tin basis is, moreover, accompanied with this *singular* circumstance, that when applied separately to the linen or cotton intended to be dyed, and when these substances, after the usual drying and rincing, are dyed with the bark, the colour (contrary to what happens with the aluminous basis) proves much more fugitive than it does when the solution of tin and decoction of bark are first mixed together, and afterwards applied to the linen or cotton prosubstantively; nor have I ever been able to apply any of the solutions of tin, even in small quantities, mixed with an aluminous mordant upon linen or cotton, without perceiving that the colour afterwards obtained thereby from bark, was much less durable in respect to sun and air, than it would have been with an aluminous basis only.

Zinc, dissolved by different acids, and employed as a basis for dyeing with quercitron bark on linen and cotton, produces brownish yellows, inclining more or less to the olive and drab colours; they seem, however, less durable than the like colours, which may be more conveniently and cheaply given by substituting solutions of alum and of iron, mixed in different proportions, as mordants.

Bismuth being dissolved in nitro-muriatic acid, and the solution afterwards sufficiently diluted by water, and cotton being soaked therein for two hours, then immersed in lime-water, dried, rinced, and dyed with quercitron bark, it took a very high and full, but at the same time a brownish yellow, of considerable durability.

Copper, dissolved in the sulphuric, the nitric, muriatic, and acetous acids, and afterwards sufficiently diluted

with water, being applied to linen and cotton as a mordant, enables them to obtain from quercitron bark, by dyeing, different shades of full, but brownish yellow, which, however, does not long bear washing with soap, or exposure to rain, sunshine, and air; the oxide of copper on which the colouring matter is applied, being readily acted upon by all these agents. Soaking the linen or cotton in lime-water, when impregnated with the oxide or solution of copper, previous to the dyeing with bark, renders the colour more durable.

Cotton, having been soaked two hours in a diluted ammoniate of copper, and then hung out to dry, appeared at first of a fine blue colour, but afterwards became of a very beautiful bluish green. A bit of this cotton being dyed for a few minutes in a decoction of quercitron bark, became of a fine yellowish green: another bit dyed in the same decoction for a longer time, became of a dark brownish yellow colour; this was, however, changed to a lively yellowish green, by washing with soap, and suffered but little during three weeks exposure to sunshine, air and rain.

Linen or cotton soaked in a diluted nitrate of lead, then in lime-water, and afterwards rinced, and dyed with quercitron bark, took a kind of nankeen brown colour, somewhat, though not very, durable.

The other solutions of lead, appear to be still less useful as mordants upon cotton, for dyeing with the bark.

Manganese being dissolved by a very weak or diluted sulphuric acid, and the solution afterwards mixed with an additional portion of water, cotton was soaked therein for two hours, and afterwards immersed in lime-water, then rinced and dyed with the bark, from which it obtained a nutmeg brown colour, inclining slightly to the olive, which proved somewhat lasting.

The oxide of arsenic is capable of serving as a mordant for the quercitron colouring matter, but as the shades produced by it may be obtained by cheaper and much less dangerous means, I cannot recommend its use for this purpose.

Cotton, soaked in a diluted nitro-muriate of gold, afterwards rinced and dyed with quercitron bark, received a delicate olive-tinged yellow of considerable durability; but this mordant is much too expensive to be used in this, or in almost any other way.

Cotton, first dipped in a weak solution of soda, became of a yellowish brown by being soaked in a diluted solution of platina by the nitro-muriatic acid, and being afterwards dyed with the bark, it became of an olive colour.

Cotton, dipped in a weak solution of soda, and then in a diluted solution of the grey ore of cobalt, (*cobaltum galena*,) by the muriatic acid, became first green and then yellow; and this being afterwards dyed with quercitron bark, the colour changed to a lasting black. The pure cobalt, dissolved either by the muriatic or the nitric acids, and applied in this way to cotton, produced a cinnamon brown colour, with the quercitron bark.

Cotton, wetted with a solution of soda, and then with a diluted nitrate of nickel, became green, and being afterwards dyed with the bark, it became of a full cinnamon brown.

Iron, though I mention it last, seems to be the most useful of the metallic bases, for dyeing on cotton and linen with the quercitron bark, and more especially for producing the drab, mud, dove, and olive colours, with the great variety of shades which result from a mixture of these upon cotton velvets, velverets, fustians. &c. These colours have hitherto been commonly dyed from what is called the old fustic, (*morus tinctoria*,) though

they may be given more cheaply and conveniently with the quercitron bark in the same ways, and when so given, are more lasting than those given by fustic, as I have repeatedly found by exposing samples of each to rain, sun, and air, for the space of six months together.

The cheapest form in which iron can be employed in this way, is that wherein it is dissolved by sulphuric acid, as in the common sulphate of iron, or green copperas; and, after many trials, I have not found any other combinations of this metal capable of producing effects so much better in dyeing as to compensate for the increased expense attending their use. Copperas and quercitron bark, in different proportions, produce all the different shades of the *drab* colour, from the deepest to the lightest; and for this purpose, the copperas may be either dissolved in a decoction of the bark, and the pieces of cotton velvet, velveret, or fustian, turned through the liquor (of a suitable heat) by the winch, or the bark may be boiled with water in one vessel, and the copperas dissolved by warm water in another, and the pieces passed as usual, first through the latter, and then through the former, and so alternately from one to the other, until the proper shade is acquired; and by adding after the rate of one pound of chalk to eight pounds of copperas, in the vessel wherein this last is dissolved, the colour will be rendered more durable, and at the same time changed a little to the chocolate brown.

To produce the olive shades, sulphate of copper, (blue vitriol,) with about one-eighth part of its weight of chalk, or alum with a like proportion of chalk, may be employed along with the copperas, so as to give the drab colour a sufficient inclination towards the yellow hue; and for this purpose, the blue vitriol is, I think, preferable to alum.

For the drab colours, one or two pounds of copperas, according to the fulness of colour wanted, with about three times as much of bark as of copperas, and a little chalk, will suffice to dye 100lbs. weight of velvet, velveret, or fustian: and for the olives, it will only be necessary to diminish the quantity of copperas according as the shade is wanted to incline more or less to the yellow, and add as much or a little more blue vitriol in its stead: and for this purpose, the blue vitriol may be either dissolved in the same vessel with the copperas, (and chalk,) or it may be dissolved with chalk in a separate (third) vessel, and the velvets or fustians, after they have been turned or worked sufficiently in the two first vessels, containing, one the copperas liquor, and the other the bark liquor, may be turned or worked in the solution of blue vitriol in the third vessel, until it inclines sufficiently to the yellow hue; and, perhaps, this method will generally be found most convenient to fustian dyers, who are frequently required at the same time to dye a great variety of different shades. But otherwise, it probably would be most advantageous to turn and soak the pieces for a little time in the solution of copperas and chalk, or of copperas, chalk, and blue vitriol, (or alum instead of blue vitriol,) then immerse them for a few minutes in lime-water, and afterwards rince and dye them in a decoction of bark, by which colours much more lasting, and much less liable to spot than those commonly obtained, might be dyed; it would, however, be more difficult in this way to produce that great variety of shades, which in the other are easily attained by any dyer accustomed to the use of old fustic for the like purposes, as I well know by my own experiments, and by those of others. One pound of bark will commonly produce as much effect as four pounds of old fustic.

When darker colours are wanted than can be conveniently given with the quercitron bark and copperas, a portion of Spanish sumach may be added to obtain them, as is done for saddening the colours given with old fustic and copperas; though it is possible to produce a durable colour, approaching very nearly to a *perfect black*, by the quercitron bark and the iron basis, by first soaking the cotton in a weak solution of barilla and liver of sulphur, then drying and immersing it in a diluted solution of iron, by the nitro-muriatic acid, and afterwards dyeing it with the bark.

Of the Application of Quercitron Bark in Topical Dyeing, or Calico Printing.

Between pages 257 and 283 of my former volume, I have given a general, though summary, account of the art of calico printing, as practised during many ages by the inhabitants of India; and also of the improvements which have followed the introduction of this art into Europe. I have also particularly described the two principal mordants or bases employed to fix and raise the different adjective colours, by topical or partial dyeing; I mean the printers' aluminous mordant, or acetite of alumine, and what is called iron liquor, (acetite of iron,) made by dissolving that metal in vinegar, sour beer, &c. These mordants the calico printers have very improperly named colour, or colours, though they only afford the basis, or bases, of colour, to be afterwards obtained from madder, weld, quercitron bark, &c. For an account of the preparation of acetate or sugar of lead, and of the substitutes for it, in making the aluminous mordant, I cannot do better than refer my readers to M. Berthollet's chapter on that subject, and to the writers therein mentioned, and, for an account of the true nature and advantage of this aluminous mordant, my

readers will be pleased to recur to pages 266, 267, &c. of the former volume. Of the iron liquor, it may be proper to observe, that, when made with vinegar, that which has been longest kept is most esteemed. But of late much is consumed which has been prepared by dissolving iron more expeditiously in the pyro-ligneous acid, obtained by distillation from wood, and it is probable that, in some cases, the action of this acid has been strengthened by an addition of the muriatic, though this last must have a tendency to render the solution corrosive.

Linens or cottons before they are printed, require to be bleached; and the more perfectly this operation is performed either by the old or new method,* the less will the parts intended to remain white be afterwards stained by the madder, weld, or bark, liquors in dyeing; and the more easily will any discoloration from these liquors be afterwards discharged. After bleaching, the pieces will need to be calendered, in order to produce a smooth surface, and render the woof and shoot as even and square as possible, and thereby favour a due application of the mordants; which, being properly thickened by starch, flour, or gum, as formerly mentioned, are to be applied by blocks, plates, cylinders, &c. as those employed in this part of the business sufficiently understand. This being done, the pieces are to be well dried in a stove heat, so as to evaporate the acetous acid, which held the basis in a state of solution, and cause the latter to be more copiously deposited and fixed in the pores of the cloth.

After drying, the cleansing operation follows; and

* M. Widmer, of Jouy, thinks that calicoes bleached by the oxymuriatic acid, not only become whiter, but afterwards take the different colours with better effect than when bleached by other means.

this is performed in a copper with water, nearly as warm as the hand can well bear, and a quantity of fresh cow-dung; in which the pieces are to be briskly worked, so as to dissolve the thickening of the mordant, or mordants, and separate all the unfixed superfluous particles of alumine, or of iron, which the cow-dung serves to entangle, and thereby hinder them from spreading and attaching themselves to the parts intended to be kept white, and there becoming the basis of a future stain, or discoloration, which it might be difficult to remove; after this, the pieces, being thoroughly soaked and well rinced in clean water, will be fitted for dyeing with the bark.*

In many cases, madder colours are mixed in the same piece with those of the bark; but in these the madder ought to be first dyed on a separate course of work, in which the mordant, or mordants, are printed only so far as the madder colours are intended to extend; and the piece being then dried, cleansed, and dyed with the madder, and afterwards whitened by branning and bleaching, are to be calendered, and made ready to receive a second course of mordants for the bark, in which the pieces are to be printed, dried, cleansed, &c. as just mentioned.

My readers have been already informed, that the bark produces a good bright yellow with the aluminous mordant, and a drab colour with the iron liquor; and that both together, mixed in different proportions, pro-

* To save time and trouble, calico printers often cleanse (if I may use this term) too many pieces of printed calico in the same deficient quantity of water, (with cow-dung,) which thus becomes overloaded with the mordants, containing iron, with galls, logwood, &c. which are frequently mixed with them, and which, by combining with alumine in the parts intended to be dyed yellow, necessarily degrade the latter colour.

duce different shades of olive and olive-brown colours. And that if a strong decoction of galls be added to the iron liquor, and the mixture applied in the same way to linen or cotton, it will, by dyeing with the bark, produce a black sufficiently fixed, though inclining a little to a brownish hue. By means, therefore, of the aluminous mordant and the iron liquor, three very distinct colours, besides the black, are obtained from quercitron bark: and, moreover, by applying the aluminous mordant upon a madder red and an indigo blue, an orange in the first case, and a green in the second, will be produced when the piece comes to be dyed with the bark.

I have already noticed (at page 263 of Vol. I.) the practice of colouring the solution of alum, in the East Indies, with sampfan, or sappan, (red) wood; a practice which the the calico printers of Europe have imitated, by colouring the aluminous mordant with Brasil wood, (and thence calling it *red* colour,) not only when it is intended to serve as a basis for the madder red, but also for the quercitron or weld yellows; though in the latter case, at least, the practice ought to be laid aside. It is, indeed, necessary that some tinge should be given to mordants in calico printing, in order that the printer may readily discern the exact progress and extent of his work: but it is much better to give this tinge, from quercitron bark, to figures, or parts intended afterwards to receive the bark or the weld colours by dyeing, than to give it from Brasil wood; the colour of which, were it to remain, would hurt the true yellow intended to be afterwards fixed upon the aluminous basis: but the false Brasil colour, not having so much affinity with the basis as to be able to maintain its situation, is always dislodged by the superior affinity of the bark or weld. This dislodgment, however, of one colouring matter by the application of another, takes up some time, and unne-

cessarily prolongs the dyeing process (the yellow in this case rises more slowly); and the parts intended to be kept white are also rendered liable to a greater degree of stain or discoloration. But where the mordant has been tinged with the quercitron bark, a portion of the colour intended to be given is already applied to the basis; and, though at first not perfectly fixed upon the linen or cotton, it soon becomes so in the dyeing vessel; whilst the additional colouring matter of the bark, having no false Brasil colour to dislodge, applies itself without impediment to the aluminous basis, and produces the requisite degree of colour much more quickly, as may be easily seen upon a proper trial.

I do not, indeed, think that any degree of tinge ought to be thus given, even from the bark, *beyond* what is necessary so enable the workman to see his work with sufficient clearness; because the particles of alumine or of iron, when previously united to any species of colouring matter, do not seem by cold application to fix themselves either so intimately or so *copiously* in the fibres of linen or cotton, as they do when applied without any such union or incumbrance; and I have repeatedly found, that yellow colouring matter, dyed upon an aluminous basis *untinged*, produced a more lasting colour than it does upon a basis previously tinged even by quercitron bark, and much more lasting than where the tinge had been given with Brasil wood. And this fact will enable us to conceive one, at least, of the reasons why it is most advantageous, in dyeing upon linen or cotton, to apply the aluminous basis first by itself alone. But, in topical dyeing with the quercitron bark, or with weld, wherever it is necessary to give a moderate degree of tinge to the mordant, whether aluminous or ferruginous, (i. e. iron liquor,) or a mixture of these, I advise it to be given by a decoction of the bark made

very strong, that it may not too much weaken the mordant, and at the same time employed as sparingly as the nature of the case will permit.

The effect of mordants topically applied, often depends greatly upon their being either too much or too little thickened with gum, starch, or flour, which are usually employed for this purpose. When the liquor has been too much thickened, it does not sufficiently penetrate the fibres or substance of the linen or cotton, and, therefore, the colour raised upon it proves weaker and less durable than it otherwise would do; but, on the contrary, if the liquor be not sufficiently thickened, it runs, or spreads, too far upon the surface of the piece, and produces figures, or impressions, which prove confused and undefined. In general, the liquor for this kind of application, should be made so thick, and only so thick, as barely to prevent its spreading beyond the proper limits; and it seems more necessary to catch exactly this point of thickness, or fluidity, with the iron liquor than with the aluminous mordant, because the oxide of iron does not combine so intimately as the alumine does with the acetous acid; but, on the contrary, it remains suspended in a less divided state, and neither penetrates so freely, nor unites so intimately, as the particles of alumine with the linen or cotton to which it is applied; and, therefore, the iron liquor in particular ought never to be thickened any more than is necessary to hinder it from spreading too far.

When the mordant has been applied, and has had sufficient time to penetrate the substance of the cloth, it should be thoroughly dried in air artificially heated, as before mentioned, so as to evaporate not only the water, but as much as possible of the acetous acid united to the alumine, or to the oxide of iron, in order that nothing may remain to oppose their intimate union with

the fibres of the linen or cotton, which the water, and more especially the acid, necessarily would do by exerting their own particular affinities upon the substances intended to be thus intimately united. It will, however, be impossible in *this* way to evaporate the *sulphuric* acid, of which the aluminous mordant, made with the usual proportions of alum and sugar of lead, always contains a little; and which, when the pieces are brought under the cleansing operation, enables the warm water to re-dissolve and separate a part of the alumine, wanted for raising and fixing the colours intended to be afterwards given by dyeing; which alumine, being so redissolved and separated, is apt, even in spite of the viscidity and entanglement of the cow-dung, to fix itself again upon those parts of the linen or cotton intended to remain white, and occasion a much greater and more lasting degree of stain, or discoloration, than would otherwise take place in the dyeing vessel. These effects might, indeed, be obviated, by mixing a little lime or chalk with the cow-dung and water employed for the cleansing, so as to neutralize the sulphuric acid; but, by so doing, a sulphate of lime would be produced; and this, by fixing itself on the parts intended to be kept white, would give them a calcareous basis, and occasion another kind of stain, or discoloration, almost as bad as that intended to be thus prevented. But carbonate of potash or of soda used in this way instead of lime, will answer the purpose of neutralizing the sulphuric acid, without communicating any improper basis of colour, so as to occasion that kind of stain or discoloration which it is so desirable to avoid; though if any more of it be used than what is sufficient barely to neutralize the acid in question, it will exert a mischievous action, by dissolving a portion of the aluminous basis fixed upon the linen or cotton, and render the yellow, after-

wards communicated by dyeing, more feeble than it otherwise would have been. A *very little* of the mild alkali may, however, be used in this way with advantage, so as to leave the pieces capable of receiving full strong colours, whilst the parts intended to remain white will be but very slightly discoloured by the dyeing process, and afterwards easily whitened.

It is in all cases of great importance, that the cleansing operation should be well conducted, and thoroughly performed; but more especially where a large proportion of drab, dove, and olive, colours are to be intermixed with yellows; because the oxide of iron, which serves as a basis to the former, is very apt to attach itself too copiously to the linens and cottons on which the iron liquor is printed; and unless the redundant part be carefully removed in the cleansing operation, (which is a work of some difficulty,) it will remain, and be afterwards attracted and separated by the colouring matter of the bark in the dyeing vessel; and, uniting therewith, it will give the dyeing liquor an olive or drab-colour tinge, and greatly tarnish the yellow figures, or designs, as well as stain the parts intended to be kept white: and, therefore, whenever the iron liquor is to be printed upon the same piece with the aluminous mordant, the former should be diluted as much as it will bear, without making the liquor too weak to afford a sufficient basis for the colour intended to be afterwards dyed upon it. By such dilution, joined to proper care in cleansing, the yellows may be made to come out of the dyeing liquor perfectly untarnished; which otherwise they will not do, at least when accompanied with any considerable proportion of figures, or designs, which have been printed with iron liquor.

Having premised thus much concerning the operations of printing and cleansing, I now proceed to that

of dyeing with the quercitron bark. For this, a suitable portion of the bark, previously ground, is first to be put into a dyeing pan, or vessel, with cold water, and the pieces to be dyed immediately after; a small fire is then to be lighted under the pan, so as gradually to warm the water; and, while this is doing, the pieces are to be slowly turned by the winch, in order that the colouring matter may apply itself equally: when the liquor becomes a little more than blood-warm, the colours will take sufficiently quick, and prove more lasting than they do when raised more hastily; because in a moderate warmth the colouring particles (as was before observed) have time, and are enabled to adjust themselves more accurately, and unite themselves more closely, to the particles of alumine, than they can do when hastily thrown and accumulated by a greater heat upon the printed figures or designs. And I have repeatedly found, that samples slowly dyed with the bark in this way, being exposed to the sun and air along with others dyed more expeditiously in a boiling heat, proved much the most lasting. And if the quercitron yellow has at any time been found less durable than that of the weld,* it

* Berthollet, in the last edition of his Elements, &c. has appropriated a chapter exclusively to the quercitron bark; which he begins with the following observation: " C'est a Bancroft que l'on doit l'acquisition de cette substance tinctoriale: il a donné une ample description de ses propriétes et des usages auxquels elle est propre: nous allons en presenter le sommaire," &c.; and after having done this, he adds " on doit indubitablement regarder le *quercitron* comme une substance tres utile en teinture;" but after thus bearing testimony to its utility, he intimates a belief, that the colour which it affords is not so lasting as that of weld. But if there should be, as has sometimes appeared probable, some little foundation for such a belief, the difference is much more than compensated by the great advantage which the quercitron bark possesses of producing no discoloration to the grounds, or parts intended to remain white, sufficient to require a similar exposure on the grass by which the

can only have been so, through some defect in the mode of dyeing, at least if there was none in the mordant. Hitherto the bark has generally been used with too much heat *at first.* I say at *first*, because after the colour has been slowly raised, by liquor moderately warm, to nearly the proper height, a boiling heat will do no harm, excepting that of occasioning a little more stain or discoloration upon the parts intended to remain white; and though the avoiding of this is an additional motive for applying the bark in water of a moderate warmth only, yet this of itself might not be a very powerful motive, because such stains from the bark are much more easily removed than those resulting from weld. But the most essential difference between these vegetables, respects the degree of heat by which their several colours are most permanently fixed upon linen or cotton; that of weld requiring at least a scalding, if not a boiling, heat to render it lasting, whilst the bark colour, as has been already observed, proves most durable when applied in water but little more than blood-warm. And, indeed, I have found, during the summer months, that cottons printed with the aluminous mordant were able to imbibe a good, though not a very high, yellow, by only remaining a few hours with bark in water of the heat of the open air, (in which it was placed,) and without any considerable stain or discoloration upon the parts not printed. A piece of the calico so dyed in the heat of the atmosphere only, being cut off and further dyed with the bark in boiling water, it imbibed a greater body of colour; but a sample of this, and of the former or paler yellow, being equally exposed to the sun and air, I found at the end of three weeks, that the latter, which had

weld yellows always suffer, and are often greatly injured, particularly in winter, when the bleaching process is often necessarily continued several months.

been the deepest, retained no more body than the other; the additional colouring matter, which in a boiling heat had been enabled to apply itself upon the aluminous basis, having been all discharged during this exposure to the weather. A fact which seems to indicate, that when the alumine has attracted to itself a certain portion of colouring matter, any addition made to it afterwards by the aid of heat, will be less permanently fixed, and, therefore, liable to be more speedily removed by any of the causes which usually contribute to the decay of colours.

All the different shades of yellow may be obtained from the quercitron bark by varying the quantity, and applying it with greater or lesser degrees of heat during a longer or shorter time. By using the bark sparingly in water only blood-warm, pale delicate yellows may be raised in about fifteen or twenty minutes, and the parts intended to be kept white will receive scarcely any discoloration; by a larger proportion of bark, and by keeping the pieces for a longer time in the dyeing liquor, though without increasing its heat, a full and clear lively yellow may be produced; and by a still greater proportion of the bark, and a prolongation of the dyeing operation in a scalding heat during the latter part of it, the colour may be raised, first to a high golden, and afterwards to a very full brownish yellow. The quantity, therefore, of bark to be employed, must always depend upon the nature and closeness of the figures and impressions which are to be dyed, and the height or fulness of colours intended to be produced. Commonly, however, one or two pounds of bark will suffice for each piece; but, where too little has been employed at first, a farther quantity may be afterwards added without inconvenience; and, when the dyeing is to be performed in a very moderate heat, it will always

be most advantageous to employ a little more bark than is necessary; which may be done without any loss of colouring matter, because other pieces may be afterwards dyed, with a farther supply of bark, in the same liquor; and I have found that yellows, whether dyed from bark or weld, commonly prove most durable when the dyeing liquor has been somewhat plentifully stored with colouring matter; and, in general, I think it best to employ the bark so freely, as that the liquor may be strong enough, without being made more than blood-warm, to produce full bright yellows in the space of half or three quarters of an hour; the tinge, or discoloration, which the parts not printed imbibe from the bark in this way not being half so great as that produced by weld, and it being afterwards discharged with less than half the time and trouble which even an equal degree of stain from the latter would require. Indeed, where the pieces have been at first well cleansed from all loosely adhering and superfluous particles of the aluminous or ferruginous bases, the discoloration from bark generally proves so inconsiderable, that by rincing or washing them in cold, and more especially in warm water, it may be sufficiently removed without either branning or bleaching, excepting where the unprinted parts are required to be uncommonly clear and white: and when this is the case, I think it best to add after the rate of one pound of cream of tartar, in powder, for every twelve or fourteen pounds of bark, putting the tartar into the water immediately after the bark, and then dyeing the pieces, as I have already explained. The tartar used in this way will contribute much towards keeping the white or unprinted parts free from stain or discoloration; and it will, moreover, give the quercitron yellow that bright, clean, and delicately greenish hue which is sought for in the weld, so as to make

the former resemble the latter. But, as the tartar tends to keep the quercitron yellow from taking so fast, or rising so high, as it would otherwise do, the liquor may, in this case, be made hotter in the latter part of the operation. On the contrary, if, instead of tartar, one pound of clean white potash be added for every thirty pounds of bark, a very high, and, at the same time, a very bright yellow will take so quickly, that the liquor should never be more than blood-warm: and, though the unprinted parts may seem a little more stained than they are when no potash is used, the stain will be discharged by thoroughly rincing and washing the pieces as usual.

Some calico printers, not acquainted with the best methods of employing the bark, have thought proper to join with it a little of the decoction of weld:* I cannot, however, recommend this practice, because, in truth, the bark, when properly used, wants no such assistance, and because the colouring matter of the weld does not take permanently without a greater degree of heat than ought to be employed with the bark. It moreover occasions a much greater stain upon the unprinted parts, and at the same time degrades the madder reds and purples, (where these colours have been previously dyed,) much more than the bark.

It is to be observed, that the very moderate warmth, which best suits this kind of dyeing with the bark, does not, in general, completely extract its colouring matter, at least from such parts thereof as are not finely ground; but, being tied up in a bag, it may be afterwards boiled separately in water, and the decoction so made may be employed for dyeing olive and drab colours, where they are not intermixed with yellows or reds. Some calico

* This practice seems no longer to exist.

printers have, indeed, thought it best, in all cases, to begin by boiling the bark in a small quantity of water, so as fully to extract the colouring matter, and then, for yellow, as well as drab and other bark colours, to put a suitable proportion of the decoction into the dyeing vessel, with clean warm water, and dye the pieces therein, adding more of the decoction as wanted from time to time. I do not, however, think this practice so convenient as that which I have recommended.

A very ingenious printer in a distant country, and warm climate, some time since, favoured me with an account of his method of using the bark, which he considers as one of the best: "I pound (says he) the bark, and boil it in a good quantity of water, say twenty-five gallons to seven pounds of bark; after which I let it settle, and pour off the clean decoction; of which I add a portion to a tub full of clean cold water, and immediately, with the hand, pass a quantity of clean rinced (printed) cloths through the water; they take on colour very quickly, and it appears fresh and beautiful: I then add another portion of the decoction, and bring out a pretty full yellow; meanwhile I have my large copper ready with clean water as warm as the hand can well bear, and to this I add also a portion of the decoction; and then remove the cloths from the tub into the copper, and turn them quickly round; by which method I obtain the best and most durable yellows: ten or fifteen minutes will be long enough to keep the cloths in warm water, where a delicate yellow is required." "I found it easy," continues the writer, "to manage the olive and drab colours in the copper; for *these*, I use the bark which has been once boiled for the yellow; seven or eight pounds of it are to be boiled in twenty-five gallons of water, and then the whole is to be thrown into a copper containing about 250 gallons; through which I pass

about 225 yards of cloth perfectly well rinced, or, if it be heavy work, only about 180 yards, which are to be turned quickly round: I begin with a moderate fire, which, in half an hour, is to be raised so as to make the water almost boil. Here, and especially for *dove* colours, I use a little sumach, which requires considerable heat before it produces any good effect; and, therefore, I think it useless for yellow, which the bark produces with so little heat. I have seldom allowed more than an hour for such olives, drabs, and doves; and I never join yellows with them, because the grounds will in this way be so much stained as to require more bleaching than the yellows can bear without injury; but doves, olives, and drabs, stand the bleaching, and remain unimpaired after the grounds are become perfectly white." This account the writer concludes by saying, "I have been able to do more variety of work with the bark than with any other colouring matter yet known; it is pleasing to work with, as it takes effect quickly, and is very easily managed by any person who knows the business of neutralizing salts, and preparing cloth to receive colour."

The rule which this gentleman seems to have prescribed to himself, of never joining the drab and dove colours to the yellow, is, I believe, much too rigid; for though, in truth, it is impossible to dye perfectly bright yellows where they are intermixed with any considerable proportion of what is called the *black colour*, and difficult to do it where the drab and dove colours abound very much; yet, in the latter case, this difficulty may be very much diminished by using the iron liquor of no greater strength than is necessary, and taking care to have the pieces thoroughly cleansed (as lately mentioned) before they are put into the dyeing vessel: if this be done, a considerable por-

tion of olive, drab, and dove colours may be intermixed, and even a little of the black, without any material degradation of the yellow. To improve the black, and darken the drab or dove colours, (which the printer is often desirous of doing,) a little Malaga sumach, (*rhus coriara*,) in powder, may be advantageously employed with the bark, after the rate of one pound of the former to three or four of the latter. It is, I believe, generally thought best to raise the colours first with the bark, and afterwards change, or darken, the doves and blacks by adding the sumach, and continuing the process until the desired effects have been produced. My own experiments, however, lead me to conclude, that time may be saved, and every good purpose attained, with equal certainty, by putting the sumach into the dyeing vessel along with the bark, and thus applying the colouring matters of both at the same time; taking care, however, not to heat the dyeing liquor beyond what the hand can bear. In this way the parts unprinted may be kept perfectly white, so as never to need either bleaching or branning. The sumach, indeed, when put into the water at the same time with the bark, and used in this way, produces, in an extraordinary degree, the effect of keeping the white or unprinted parts perfectly clear and free from all discoloration; which it probably does by means of a *particular acid*, contained in this and many other astringent vegetables: one pound of sumach to three of the bark will be amply sufficient for this last purpose; and in that proportion the sumach will make the parts printed with iron liquor incline towards a purple colour instead of the drab, which quercitron bark used *alone* would produce.

This change of colour produced by sumach will sometimes render the use of it inconvenient; but when this is not the case, a small proportion thereof joined to the

bark, as before mentioned, will prove more effectual than cream of tartar in preventing even the slightest stain or discoloration upon the unprinted parts of cottons topically dyed.

A gentleman, of whose information I have more than once availed myself, some time since brought from Bengal, and gave me, a parcel of the dried leaves and tops of a plant there called *D'howah*, and employed, as he informed me, in the dyeing of topical or field colours, by putting a small quantity of it into the copper when the colours begin to rise, in order to keep the grounds or unprinted parts clear; an effect which, upon trial, I found it to produce nearly as well as sumach; and upon dyeing a bit of cotton, which had been printed with iron liquor and the aluminous mordant, separately, in a decoction of this plant only, it imbibed colours very nearly resembling those of sumach, though the decoction itself, even when made very strong, did not discover any astringency to the taste.

The berries of the common Pennsylvanian sumach (*rhus glabrum*) are covered with a red farinaceous matter, containing a large proportion of an acid, which appears to resemble that of tartar. These berries employed with the quercitron bark, after the rate of one pound of the former to twelve of the latter, produced effects nearly similar to those of cream of tartar, as already mentioned, in preserving the unprinted parts of cottons from being stained, and in giving the quercitron yellow the pale greenish complexion which distinguishes that of weld. Such means cannot, however, be employed where very full high yellows are wanted; and when this is the case, if the grounds or unprinted parts are required to be perfectly clear and white, it may be best to employ a little clean soda in the dyeing, as lately mentioned, and afterwards to spread the pieces for a day or two upon the grass, laying

what is called the wrong side upwards, as is practised with other field colours. Those of madder and weld, indeed, always require this operation, though it cannot be wanted for those of the bark, except in the single case just mentioned; and then only for a very short time, unless it be in rainy or cloudy weather, when this kind of bleaching proceeds very slowly with all colours, because the action of the air is then not only unassisted by the rays of the sun, but obstructed by the water which it holds in a state of solution.

Messrs T. H. and son, very ingenious dyers of *printed* velverets, fustians, &c. near Manchester, some time since informed me of their having purchased the knowledge of an advantageous method of using the bark for this particular kind of dyeing, and of their having practised it with so much success as to have wholly laid aside the use of weld. This method they afterwards gave me an account of, in consequence of my offering to repay what it had cost them; which I did, from a desire to afford the public all possible information on this subject. Their account is as follows, *viz*.

" In using the quercitron bark, for every four pieces of half-ell velverets, about forty yards long, we take eight pounds of the light-coloured bark, and put it into a cask large enough to hold about seventy gallons, open at the top, and provided with a spigot and faucet, placed about six inches from the bottom, to draw off the liquor: we fill this cask with boiling water, stir it well, and let it remain upon the bark for three hours or more; and then after the (printed) goods have been well washed out of the dyeing liquor, for the four pieces we put four pounds of Malaga sumach into a copper nearly filled with water, and with a very little fire under it; in this we put and keep the goods for about one hour, during which the dove or drab colours may be rendered sufficiently dark

by keeping the liquor, at most, a little more than blood-warm. When the goods are taken out of the sumach liquor, they must be rinced in water, and whilst this is doing, we draw the clear bark liquor out of the cask, and put it into a copper with as much water as will serve to dye the goods conveniently; we then light a fire, and gradually bring the liquor to a blood warmth in about an hour, keeping the goods therein till the yellow becomes sufficiently dark or full, and taking care that the liquor be not made too hot. The goods, being well washed after dyeing in this way, will be found white without branning."

It ought to be remembered, that according to this method, the sumach is to be applied separately *before the bark*, instead of being applied *after* or *along with it*, as I have just recommended in calico printing. How far this method may be preferable to the other for the dyeing of printed velverets, future experience must determine; though, certainly, that of Messrs. H. and son ought, on this point, to have great weight, even at present. In calico printing, however, this method of applying the sumach and bark has been tried, not only by the experiments which I have made upon a small scale, but by those which an ingenious calico printer made sometime since on a larger one, at my desire; and in both, without affording any reason to prefer it over the other.*

* Some years after the preceding parts of this chapter were first published, and in consequence of M. Seguin's discovery, respecting the tanning principle in vegetables, it occurred to me to to try the effect of gelatine, glue, or animal jelly, in separating and precipitating that principle, of which a large proportion notoriously existed in this, as well as other oak barks; and with this view I added a little of a solution of the whitest glue among that commonly sold, to the water, in which I dyed bits of calico, that had been impregnated with the aluminous and ferruginous mor-

It can hardly be necessary for me to mention here, that the quercitron yellow produces a green upon an indigo blue, and an orange upon the madder red, in the

dants, and I have found, as I had, in some degree, expected, that by this separation and precipitation of *tanning*, the yellow then dyed was rendered more *delicately clean* and pure than it would otherwise have been, and that the *slight* discoloration of the white grounds, commonly observed, was, if not completely obviated, at least much diminished: since that time this use of glue has become general among the calico printers, and with so much benefit, in securing both the yellows and the white grounds from the discoloration which, though slight, had before commonly resulted from the presence of the tanning principle, that *the use of weld in calico printing, has, as I am informed, been entirely laid aside for that of the quercitron bark*, at least in this kingdom.

The following method of employing glue and sumach with quercitron bark, is extracted from a letter written by one calico printer to another.

" For dyeing the pieces, after they have been well cleansed, I recommend two pounds of the best glue, eight pounds of sumach, and eight pounds of bark, well ground, to be put together into a copper over night, if convenient; these quantities will be sufficient for six of your heavy pieces. When the copper is made a little warm, the glue, if stirred, will soon disperse itself through the water, and produce its effect upon the colouring matters, and the parts which have been printed with the mordants will speedily attract the dye; so that by proper management the grounds may be made *perfectly white*, only by washing the pieces when they come out of the copper; though you may pass them through hot water, if you think it necessary. When you have blacks and drabs to follow your yellows, the above proportions will be best; though they may be varied according to the nature of your work; e. g. you may employ to ten pounds of bark, six or eight of sumach. In all cases you may ground in the yellow on the table with the drabs, which will do away one fourth of the grounding, and you may bring all your yellows out of the copper without any stain upon the grounds. Chintz work will not tinge the lay work; and this will be the case with olive and chocolate colours; and as they never need branning, or bleaching, the colours will not be impoverished by these operations; and the whole process may be finished in less time than is required merely to boil the weld."

same ways, and by the same means, which enable the weld to produce these colours in calico printing. Nor need I mention the advantage which the bark possesses over weld in this way, by not tarnishing the madder colours upon pieces where such colours have been previously dyed; this advantage being now generally known and acknowledged.

Of the Uses of Quercitron Bark, in producing Topical *Yellow and other colours,* prosubstantively, *upon Cotton and Linen.*

By the denomination of *prosubstantive* topical colours, I mean certain mixtures, in which the colouring matter and the mordant or basis are combined in a fluid state, fit to be applied *together* by the pencil, block, &c. to linen or cotton, as explained at page 266 of volume I.; these are what calico printers have usually named *chemical colours;* an appellation too vague to be retained in a work which aims at precision and systematical arrangement.

Were it possible to obtain a sufficient number of *lasting* and *bright* colours of this kind, at a moderate expense, the art of calico printing might be practised with but little trouble, and would soon reach the highest degree of perfection. Whether so many of these ever will be discovered, as to render *topical dyeing* unnecessary, I know not; but if we cannot obtain all that is desirable, in this respect, the art will, at least, derive benefit from any improvement in the few prosubstantive topical colours now in use; and more especially from any addition to their number.

My readers already know that alumine, or the earth of alum, when dissolved, especially in the acetous acid, and conveyed into the pores of linen or cotton, is able afterwards *to attract to itself* different adjective colouring

matters, applied either by general or by topical dyeing, so as to produce lasting r d, yellow, and other colours; and it is much to be regretted that, for reasons which I have endeavoured to explain in other parts of this volume, the same mordant will not produce colours equally permanent, when it has been previously mixed with the colouring matter, and is afterwards applied (with it) topically to linen or cotton. The difference in this respect, is, indeed, very great among the madder colours; those dyed upon an aluminous basis, applied separately, being always very durable, whilst those given by prosubstantive topical application, (the colouring matter and mordant being first united,) fade and decay very speedily. The difference is, however, so much less when colours are produced in these different ways from quercitron bark instead of madder, that I can with confidence recommend the bark, as affording better and more durable prosubstantive yellows for topical application, than any thing else yet discovered. The most simple yellow of this kind which I have to offer, may be prepared in the following way and proportions, *viz.* For three gallons of prosubstantive tingent liquor, let three pounds of alum, and three ounces of clean chalk be first dissolved in a gallon of hot water, and then add two pounds of sugar of lead; stir this mixture occasionally during the space of twenty-four or thirty-six hours, then let it remain twelve hours at rest, and afterwards decant and preserve the clear liquor; this being done, pour so much more warm water upon the remaining sediment, as, after stirring and leaving the mixture to settle, will afford clear liquor enough to make, when mixed with the former, three quarts of this aluminous mordant, or acetite of alumine. Then take not less than six, nor more than eight, pounds of quercitron bark, properly ground, put this into a tinned copper vessel, with

four or five gallons of clean soft water, and make it boil for the space of one hour at least, adding a little more water, if at any time the quantity of liquor should not be sufficient to cover the surface of the bark: the liquor having boiled sufficiently should be taken from the fire, and left undisturbed for half an hour, and then the clear decoction should be poured off through a fine sieve or canvass strainer. This being done, let six quarts more of clear water be poured upon the same bark, and made to boil ten or fifteen minutes, both having been first well stirred; and being afterwards left a sufficient time to settle, the clean decoction may then be strained off, and put with the former into a shallow wide vessel to be evaporated by boiling, until what remains, being joined to the three quarts of aluminous mordant before mentioned, and to a sufficient quantity of gum or paste for thickening, will barely suffice to make three gallons of liquor in the whole. It will be proper, however, not to add the aluminous mordant until the decoction is so far cooled, as to be but little more than blood-warm, and these, being thoroughly mixed by stirring, may afterwards be thickened by the gum of Senegal, or by gum Arabic, if the mixture is intended for penciling; or by a paste made with starch or flour, if it be intended for printing.

Where gum is employed, it will be proper first to dissolve it in water, using only what is barely sufficient to produce a solution, lest a greater quantity of water should increase the mixture beyond the quantity of three gallons, for which the portions of bark and aluminous mordant here prescribed, will properly suffice, but not for more, without weakening the colour in some degree; and for this reason, it may be safest to evaporate the decoction rather more than seems necessary; because, when mixed with the other ingredients, if the

whole proves to be less than three gallons, the deficiency may be readily supplied by a little warm water.

In preparing this mixture, however, great care must be taken to thicken it only so much as may be necessary to keep it from running or spreading beyond the proper limits; since every degree of thickening, beyond this point, will hinder the colouring matter from penetrating sufficiently into the fibres of the linen or cotton, and thereby render the colour superficial and feeble.

When this prosubstantive mixture, (which I shall distinguish as No. 1,) after being duly prepared, has been applied to linen or cotton by the pencil, or otherwise, the pieces should be thoroughly dried by a stove heat, then soaked in lime-water, and afterwards streamed or placed in clean running water, to remove the superfluous colour; and if running water be wanting, other water should be copiously employed for this purpose, thickened with chalk and cow-dung.

A good lively yellow may be produced in this way, not indeed quite so lasting as that obtained when the mordant alone is applied first, and the colouring matter afterwards, by topical dyeing; it will, however, be able to bear the action of sun and air, and also of soap in washing, for so long a time, as almost to deserve the appellation of a *fast* colour.

It must, however, be observed, that this yellow, though nearly, or quite as high as that given by topical dyeing with either weld or quercitron bark, does not prove so high and full as is desirable for this mode of application; since colours which are applied by the pencil bear but a small proportion to the others with which they are intermixed, and are, therefore, required to be more *strikingly full*, that they may not be overlooked; and it is only in this respect that the colour obtained from French berries, (Rhamnus infectorius,) and called

the *berry* yellow, has given any degree of satisfaction, it being of all others the most fugitive and fallacious. To relieve calico printers from all temptation to use a colour, which, being fitted only to deceive, ought never to have been used, I have made frequent trials with the quercitron bark, joined to almost every possible mordant or basis; and of these, some have been attended with success, though the means employed in several of them, are either too expensive or too difficult of application for general use, by persons not versed in chemical operations. There are others, however, not liable to these objections; and, perhaps, all things considered, the most convenient among the several means of raising the quercitron yellow for prosubstantive topical application, and, at the same time, of increasing its durability, may be found in the nitrate of copper, and the nitrate of lime, added to the mixture, No. 1, just described.* It is, indeed, true, that some of the solutions of tin produce still higher yellows with the quercitron bark; but they are liable to at least two objections, which will be particularly mentioned hereafter.

If copper, in small pieces, be put by a little at a time, into a large open glass vessel, partly filled with single aqua-fortis, until the acid can dissolve no more of the metal; and if the solution be left open to a free access of air, it will soon be wholly converted into blue crystals, which are, what I meant at present, by the denomination of nitrate of copper. About one pound and a quarter of this salt may be added to the three gallons of prosubstantive yellow, No. 1, together with four

* A very cheap and useful composition of this kind may be made, by dissolving, in a *strong* decoction of the quercitron bark, a mixture of powdered alum, with half its weight of sulphate of copper, and one eighth of its weight of carbonate of soda—and afterwards thickening the solution by gum, &c. as usual.

ounces of pure unslacked lime, previously mixed with eight ounces of single aqua-fortis. Clean oyster-shells, or marble thoroughly burnt, will afford the best lime for this purpose; which should be beaten into powder before it is put into the aqua-fortis, to form the nitrate of lime here wanted. This, as well as the nitrate of copper, should be added to the decoction of bark, before-mentioned, soon after the aluminous mordant, and before the liquor has been thickened, by gum or paste; and the mixture should afterwards be well stirred, and kept a little more than blood-warm for half an hour before the thickening is added.

The nitrates of copper and of lime, joined in this way to the mixture of No. 1, will considerably raise the yellow colour, and also enable it, for a longer time, to withstand the action of sun and air; they will also enable the colour to bear the action of vinegar and weak acids a little better than it otherwise would, though I do not consider this last as any test of the goodness of a colour, nor as being a circumstance of any great importance. This prosubstantive colour I shall distinguish as No. 2; and, considering that the bark in this way affords a colour full as high, and infinitely more lasting, as well as cheaper, than any which can be obtained from French berries, I think those calico printers, if there should be any, who may hereafter continue to employ the latter, will show themselves strangely unmindful of their own interest, as well as of their duty to the public, and the credit of their art.

The nitrate of alumine, employed as a mordant with the decoction of bark, produces a prosubstantive topical yellow of considerable durability; but it is apt to acquire too much of a brownish complexion.

The muriate of alumine, mixed with the decoction of bark, produces in this way, effects very similar to those

of common alum; and this is also the case where a tartrite of alumine is employed. Alumine dissolved in the pyro-ligneous acid, being tried with the bark in this way, produced effects perhaps a little, though but a very little, better.

None of the solutions of alumine by potash, soda, or ammonia, succeeded as mordants with the bark, for topical application, so well as the solutions made by acids.

If a decoction be made from six or eight pounds of bark, as directed for the preparation No. 1, but without any of the aluminous mordant, and if two pounds of the nitrate of copper, lately described, be dissolved therein whilst a little warm, and the mixture afterwards properly thickened, it will produce, when applied to linen or cotton, a good prosubstantive *yellowish green*, capable of bearing exposure to sun and air, and washing with soap, so as almost to deserve the name of a fast colour. By adding four ounces of lime, mixed with eight ounces of aqua-fortis, the colour will be improved; and it may be rendered still more beautiful, and, I think, a little more lasting, by adding immediately after the nitrate of copper, one pound of ammoniate of copper, made by pouring a pound of the liquor ammoniæ, of the London Dispensatory, into a close glass vessel, with a sufficient quantity of filings, or small bits, of copper, and keeping the vessel closely stopped, until the alkali has combined with as much copper as it can dissolve, and thus acquired a very beautiful deep blue colour. This yellowish green prosubstantive mixture I shall distinguish as No. 3; and, I believe, there are no other means by which a similar colour can be obtained of equal beauty and durability.

The ammoniate of copper alone produces, with the decoction of bark in this way, a greenish yellow deserving of notice.

The acetite of copper (verdigrise dissolved by vinegar,) mixed with a decoction of the bark, and topically applied upon cotton, produces a full brownish yellow, which, however, proves not so lasting as either No. 1, or No. 2.

And the muriate of copper, with the decoction of bark, produces in this way a yellowish olive, which soon fades upon linen and cotton.

It has already been noticed, that cottons impregnated with the oxides or solutions of tin as a basis of colour, and then dyed with quercitron bark, imbibed colours highly beautiful, and capable of resisting the action of boiling soap-suds, as well as of strong acids; but, at the same time, fugitive when exposed to the sun and open air, a defect which it would have been reasonable to expect, even in a greater degree, where the tin basis, instead of being previously fixed in the cotton, was first united to the colouring matter, and afterwards applied therewith prosubstantively. A contrary effect, however, really takes place, in some degree, because the oxide of tin has greater affinity to the fibres of cotton, after a previous combination with the colouring matter, than it has separately.

If a decoction be made from six pounds of bark, as for the preparation, No. 1, (but without any aluminous mordant), and one pound, or one pound and a quarter, of the murio-sulphate of tin, so often mentioned, be added, the mixture being afterwards well stirred, and properly thickened, will afford a very bright and full prosubstantive yellow, liable, indeed, to become a little brown by exposure to the sun and air; but, at the same time, of considerable durability, and able to withstand the action of acids or boiling soap-suds. It must, however, be remembered, that the oxide of tin has a stronger attraction than that of iron, for most vegetable colour-

ing matters, and especially for that of madder; and, therefore, when prosubstantive colouring mixtures, containing solutions of tin, like that just mentioned, are applied *closely* upon madder purples, or blacks, (made such by the oxide of iron,) these latter colours will become red wherever they are touched by these mixtures. And for this reason, whenever a prosubstantive yellow is wanted to be laid immediately upon the edge of a dark madder colour, (which is most frequently the case,) it will be proper to employ the preparation No. 2.

The nitro-muriate of tin, made with about two parts of nitric to one of muriatic acid, produces, in this way, with the decoction of bark, a very high lively yellow, capable of resisting strong acids, boiling soap, &c. but very liable to become brown by exposure to the sun and air; an effect which I found lemon juice had the power of preventing, in spots, which, for another purpose, had been wetted therewith. Olive oil, applied so as to cover yellow spots or figures produced by the decoction of bark and nitro-muriate of tin, appeared to have no effect in defending or preserving the colour from injury by exposure to the sun and air; and linseed oil, applied in the same way, did manifest harm, the spots covered by it having acquired a blackish hue after a few weeks exposure to the weather. These, joined to other facts, may hereafter help us to some useful conclusions. Muriate of tin, with the decoction of bark, applied prosubstantively to cotton, affords a very lively delicate yellow; but it is less capable than the former of resisting the action of soap and of acids; nor does it long bear exposure to sun and air. This is also true of the yellow produced in this way by the tartrite of tin and decoction of bark.

The sulphate of tin, mixed with a decoction of the bark, and applied in this way to cotton, gives a kind of

cinnamon colour sufficiently lasting. Phosphate of tin produced only a dull brownish yellow with the decoction of bark. Tin, dissolved by cream of tartar, mixed with twice its weight of muriatic acid, produced, with a decoction of the bark, prosubstantively upon cotton, a very lively strong yellow, of considerable durability. I have tried many other solutions and combinations of tin with the bark, and, indeed, almost every one which it is possible to form, but without any effects better than those which may be obtained from the mixtures already mentioned. My readers, therefore, will not require a particular account of them, especially as the use of all prosubstantive yellows which contain solutions of tin, though they afford by much the highest and most beautiful colours, must prove very limited, by reason of their effect of reddening the dark madder colours.

It has been already observed, that the decoction of bark with the nitrates of copper and lime, and the ammoniate of copper, produces a good prosubstantive yellowish green; and this may be rendered darker and fuller by superadding a portion of the logwood blue. Two calico printers have assured me, that by combining the bark and logwood with particular solutions or preparations of copper, they had been able to obtain a green, for topical application, so fast as to bear the process of field bleaching without injury; and one of them declared, that it was by adding to a decoction of bark and logwood, boiled together, a suitable portion of sulphate of copper and of verdigrise, with a little potash; this last, and the effervescence which is produced, he seemed to think of importance. As yet, however, my endeavours to produce a green fully answering this description, have not succeeded, though they have several times been attended with such appearances of success, as will induce me to make farther trials. Those hitherto

made seemed to have failed principally by the want of sufficient permanency in the blue or logwood part of the green colour. A great number of experiments, made at least seventeen years ago, taught me, that a beautiful prosubstantive blue, capable of resisting sun and air for a considerable time, when applied topically upon linen or cotton, might be obtained by combining the colouring matter of logwood with the sulphate of copper and the ammoniate of copper; a fact which I communicated to several calico printers, who have acknowledged its beneficial effects.

Six pounds of logwood boiled with water, as directed for the quercitron bark, will afford colouring matter enough for three gallons of liquor when thickened; to this decoction, whilst warm and before it is thickened, two pounds of blue vitriol may be added, and as soon as it is dissolved, two pounds of ammoniate of copper, made as already explained, and the liquor, after being well stirred, may be thickened and applied as usual. By substituting the nitrate of copper for the sulphate of that metal, a dark blue may be produced, equally durable, but not so lively and beautiful; though I think this last rather preferable to the other, for the purpose of forming a prosubstantive green with the quercitron yellow; for which purpose it will be sufficient to mix as much of this logwood blue with the yellowish green, No. 3, as may serve to produce the particular shade of colour wanted; or the logwood blue may be added to the yellow, No. 2, for the like purpose. And though the greens produced in these ways are not so lasting as to deserve to be called fast colours, they are as good as any which I have yet been able to produce by uniting the quercitron and logwood colouring matters, and, indeed, are such as it may be often convenient to employ.

If a suitable portion of strong iron liquor be mixed

with a decoction of the quercitron bark, made as already directed, and the mixture be properly thickened, a prosubstantive drab colour of some durability for topical application, may be produced; and this mixed with an equal portion of the preparations, No. 1, or No. 2, will produce an olive. If a solution of iron, by a diluted muriatic acid, or by a diluted nitric acid, be employed for this purpose instead of iron liquor, it will produce colours a little more lasting; but these solutions should be employed sparingly, that they may not hurt the texture of the linen or cotton to which they are intended to be applied.

Zinc, dissolved by the sulphuric, the nitric, and the muriatic acids, separately, and mixed with the decoction of bark, produces brownish yellow colours of different shades, but none of them sufficiently lasting when topically applied upon linen or cotton.

Mercury, dissolved by the different acids, produced with the decoctions of the bark different brown and yellowish brown colours, but none of them more durable, in this way, than those afforded by different solutions of zinc.

The nitro-muriate of platina, mixed with a suitable portion of decoction of bark, and topically applied either to linen or cotton, produces strong full-bodied snuff colours, which bear the action of acids and of the sun and air.

The nitrate of silver, mixed with a decoction of the bark, produces, by topical application upon linen or cotton, strong dark brown and cinnamon colours of considerable durability.

The nitrate of lead, with the colouring matter of bark, produces in this way a drab colour of equal durability.

The nitrate of bismuth, with a decoction of the bark, produces a very full and strong brownish yellow, which

would prove lasting, were it not liable to become almost black by alkaline sulphures, by sulphurated hydrogenous gas, and sometimes by the action even of common soap.

The muriate of bismuth produces a drab colour with the bark, and the sulphate of that metal a yellow; but neither of these are lasting upon linen or cotton.

The nitro-muriate of antimony produces with the bark, a kind of snuff colour of some durability on linen and cotton; and different shades of brown were produced in this way by the nitrate and the muriate of cobalt with the bark, which, however, soon faded by exposure to sun and air.

In giving this account of the properties and uses of quercitron bark, I have had before me notes of several thousands of experiments made therewith, in almost all possible ways, and with almost all possible chemical agents. But as a detail of their effects would more than exhaust the patience of any reader, I shall content myself with stating, as I have here done, the results of those which seem most likely to prove useful; and, probably, what I have already stated is more than enough on this subject. I have, however, thought it incumbent on me to omit nothing in any degree likely to afford useful information respecting a *new dyeing drug*, first brought into use by my exertions, and which, without them, would, probably, have remained unknown as a dyeing drug for ages to come:—a drug which has already produced important benefits, especially to the art of calico printing in Great Britain; and is likely hereafter to benefit other European nations, as well as the United States of America, in an eminent degree. The consumption has, indeed, hitherto been small, compared to the probable future increase; but it has been large, considering the short time since its properties

were first made known, and the immense difficulties which attend the introduction of all new dyeing drugs: it appearing, by the act of the 13th and 14th of Charles II. ch. 2, that nearly one hundred years had elapsed before "the ingenious industry of modern times had taught the dyers of England the art of fixing the colours made of logwood." And though indigo, the most valuable of all dyeing drugs, had been known in Asia for at least two thousand years, the use of it was either prohibited or restrained for a considerable time in different European countries, from an erroneous belief that its colour was fugitive: so difficult has it always been found to bring dyeing drugs into their *due estimation*. But though the quercitron bark has been employed only for so short a time, I flatter myself that the account which I now offer of its properties and uses, will prove much more complete than any yet given of the properties and uses of any other dyeing drug, even among those which have been known for many ages. Had I done less I might well have escaped blame, "for (to use the words of Sir John Sinclair) no individual, or even *nation*, can carry any art or new invention to its ultimate state of perfection. It must be improved upon for that purpose, by the investigation and experience of others." See his "Plan of agreement among the powers of Europe, &c., for the purpose of rewarding discoveries of general benefit to society."

Article II. Of the juglans alba, or *American hiccory*. Not only the bark, but the green leaves and the rinds of the nuts of this tree, yield an adjective colouring matter so very similar to that of the quercitron bark, that all the instructions which I have given respecting the latter, will be found applicable to the hiccory; allowing only for the difference between their respective proportions of colouring matter; that of the hiccory bark

being about one-third less than what is contained in a like quantity of quercitron bark. It is this difference, joined to the greater difficulty and expense of grinding the hiccory bark, it being very hard and tough, which has enabled the quercitron bark almost wholly to supersede the use of the hiccory; for, excepting the prosubstantive topical yellows, for which it does not seem to answer quite so well, there is, perhaps, no purpose to which the colouring matter of the hiccory may not be applied with effects as good as those resulting from the quercitron bark; and I have sometimes thought, that some of the *varieties* of this tree might be preferable to the quercitron bark, for imitating the greenish lemon yellow of the weld plant on wool, with an aluminous basis. I say of some of the *varieties*, because there certainly are considerable differences between the shades of yellow produced by the several varieties of the hiccory tree; that, for instance, which Marshall calls juglans alba accuminata, produces a clear lemon yellow, whilst the juglans alba minima produces a fuller, though not a very bright, yellow; and the juglans alba odorate, a yellow which is very full and also very lively.

Generally, however, the hiccory bark employed in the way of calico printing, or topical dyeing upon linen and cotton, produces colours very similar to those of the quercitron bark, both upon the aluminous and ferruginous bases, and with no greater degree of stain or discoloration upon the parts intended to be kept white. This also is one of the vegetable colouring matters, of which the use was exclusively secured to me for a term of years by act of parliament.

CHAPTER III.

Of Madder—Rubia Tinctorum, Rubia Peregrina, and Rubia Manjit'h.

"Crescit profecto apud me certe, tractatu ipso admiratio antiquitatis: quantoque major copia herbarum dicenda restat, tanto magis adorare priscorum in inveniendo curam, in tradendo benignitatem subit."

C. PLINII *secundi Histor. lib.* xxvii. *cap.* i.

THE genus *rubia* is of the *natural* order of *stellatæ*,* which, more than any other, abounds in roots affording the *red* colouring matter. It contains seven species, which have been accurately described; though but three of these appear to have been employed by the dyers of Europe, viz. First, rubia tinctorum, Linn., or rubia tinctor, sativa, of Bauhin, (Pinax. 333,) with annual leaves, a prickly stem, and perennial root. This is properly the *Zealand* madder, and appears to have been greatly cultivated in that province, during more than three hundred years; the Emperor Charles the Fifth, having encouraged its cultivation, by particular privileges conferred on the inhabitants of Zuyderzee, for that purpose; and Great Britain alone is supposed for a long time to have paid annually two millions of guilders (nearly 200,000 pounds sterling) for the purchase of Zealand madder;† which is, I believe, never exported

* i. e. Having their leaves set round the joints of the stem, in the form of a *star*.

† Berthollet appears to think it uncertain whether the madder of the ancients was similar to ours; though I cannot discover any sufficient reason to doubt of its having been one of the species now employed by the dyers in Europe. It is, indeed, true, that in regard to this, as well as most other productions, the descriptions left by the Greeks and Romans are not so pointed and characteristic as they ought to have been; but as far as they extend in this instance, they accord very well with the common dyer's madder. Dioscorides, under the name which it bore among the Greeks of

otherwise than in a prepared state. To bring madder into this state of preparation, the roots, after being extracted from the earth, freed in some degree from the dust, and dried by a stove heat, are placed upon concave oaken blocks, each having six stampers plated at the bottom with iron bands, which (stampers) are moved or worked by horses with suitable machinery. The first pounding separates and brings into the form of a powder the very small roots, with the skin or husk of the larger ones, and any earth which may have been left adhering thereto; and this powder being sifted, is packed separately in casks, and sold at a low price under the name of mor *mull;* but is commonly known in this country, only by the latter of these names, and employed exclusively for cheap dark colours. A second pounding separates about one-third of the remaining part of the larger roots, and this being sifted and packed separately, is denominated gort *gemeen*, ordinary powder,

Ερευθεδανον, (Eruthodanon,) describes its long square stem as being armed with hooks, and its leaves as being placed in the form of a *star* around the joints; and after mentioning the colour of the fruit, as changing from green to red, and, finally, to black, he adds, that its long slender roots are *red* and serve for *dyeing;* and that, for this purpose, they are cultivated with great profit in Galilea, and about Ravenna, in Italy, as well as in Caria, &c. (See lib. iii. cap. 160.) The description of Theophrastus (Hist. Plant. ix. c. 24.) agrees very well with this by Dioscorides: Pliny mentions madder, with its use for dyeing wool, &c., in three several places, under the name which it now bears, of *rubia*, adding its Greek name; in one of them (i. e. lib. xxiv. cap. 11.) and in lib. xix. cap. 3, he says, " it grew both wild and by cultivation from slips; and that the madder of Italy was most esteemed, especially that which grew around the villages near Rome;" he then compares it to a species of *vetch*, (ervilia,) and adds, that it had a prickly stalk with joints, surrounded each by *five* leaves spreading in form of an *orb* or *star*. " Verum spinosis ei caulis: geniculatus hic est, quinis circa articulos in orbe foliis."

(of madder,) and sold here under the name of *gemeen* or gemeens. The third and last pounding comprehends the residue, or *interior*, *pure*, and *bright* part of the roots, which, according to Mr. Miller, is packed under the name of "*kor kraps;*" but in this country, it is simply called *crop* madder.* Sometimes, after the *mull* has been separated, all the remaining part is ground, sifted, and packed together, under the name of onberoofde, which consists of about one-third of the gemeen, and two-thirds of the crop. In Zealand the madder is dried by a very moderate heat; and the last pounding is chiefly performed by night; day-light being thought to detract from the brightness of the colour. Crop madder, if exposed to a damp atmosphere, attracts moisture, and is soon greatly injured by it.

If the roots of madder be examined with a magnifying glass, the interior part will be found to contain a considerable proportion of specks or particles of a *bright red* colour, intermixed, or in contact with a kind of ligneous substance, which, as well as the cortical part, seems, unfortunately, to abound with a sort of brownish yellow colouring matter, called *fauve* by the French; and this contributes to degrade the *fine red*, which madder would otherwise afford; though the degradation may, in some degree, be obviated or diminished by extracting the colouring matter in water, which is but moderately warm; the brownish yellow tingent matter not being soluble so readily, and in so great a proportion as the other, so long as the heat of the menstruum is below the boiling point. There is, also, another difference, which is, that the brownish yellow tingent matter, does not attach itself so permanently as the *red*,

* The *mull* is called "garance *courte*" by the French—the gemeen, "garance *mi-robée;*" and the crop, "garance *robée*"—and also "garance *grappe*."

to the aluminous basis; and of this the dyers of the Turkey red avail themselves, by separating and discharging the former from the latter, after both have been applied or dyed upon the cotton yarn, &c.; employing, for this separation, a solution of soap with water heated often above the boiling point; and thus obtaining a colour equal in beauty to any which cochineal would produce upon a *similar basis.* But this method of *purifying* the madder colour, by an abstraction of the brownish yellow part, cannot be employed upon wool, which at a degree of *heat so elevated*, would be greatly injured by soap.

Water of the ordinary temperature of the atmosphere, may be made to dissolve and extract nearly all the red colouring matter from madder; but to do this, it must be copiously employed; and the colour will be more beautiful when the extraction is performed by cold, than if performed by hot water: alkalies increase the solvent power of water, and especially in regard to the brownish yellow (or fauve) part of its colouring matter; whilst acids weaken or reduce the red part, if allowed to act upon it when *un*supported by an aluminous or other basis; water is capable of dissolving a larger proportion of the brownish than of the *red* tingent madder; but for this purpose it requires a greater degree of heat.

Bartholdi asserts, that the roots of madder contain a large proportion of sulphate of magnesia; and Braconnot found in them a very considerable quantity of potash, neutralized by the malic acid. See Ann. de Chimie for June, 1809. D'Ambournay, and some others, have pretended that the roots of madder might be most advantageously and economically employed when fresh gathered; but this pretence is contradicted by the general experience of dyers, who find that, if properly dried,

and afterwards carefully secluded from moisture, they will improve by being kept one or two years, even in powder.

Of the application of Madder to Wool and Woollen Cloth.

Though the red colour dyed from madder, upon wool impregnated with the *aluminous* basis, is less bright and beautiful than that of cochineal, it has the advantage of being cheaper and more durable; and for these reasons it is greatly employed, especially upon the cloth worn by British soldiers: of the application of this basis (with tartar) upon wool and cloth, as a preparation for this and other extractive colouring matters, I have already given a sufficient account, at, and between pages 285 and 289 of my first volume; and though Scheffer has directed a much larger proportion of tartar to be employed in this preparation, I am confident that he has done so without reason, and that no advantage would result from such an augmentation of it. Wool or cloth being prepared, as described at the pages just mentioned, and good crop madder, at the rate of from four to eight ounces for every pound of wool or cloth to be dyed (according to the quality of the madder, and fulness of colour required) being put into a suitable quantity of water in the dyeing pan, and the water being gradually warmed, until it has become almost as hot as the hand can well bear, the prepared and moistened wool or cloth is to be dyed therein, by the usual management, taking care not to employ more than a scalding heat, until the colouring matter has been sufficiently applied; after which, it is commonly thought expedient, (in order more effectually to *fix* the colour,) to make the liquor boil a few minutes, before the wool or cloth is taken out of it. In large dye-houses, more than 600lbs. in

weight of cloth, is frequently dyed with madder at a *single* operation; and when this is finished, and the red part of the madder colour taken up by the cloth, the liquor appears to be highly charged with the remaining yellow part, which, not having so much affinity as the red for the aluminous basis, is not taken up by it in an equal proportion, so long, at least, as the heat continues below the boiling point.

Whether the colour be in reality fixed more permanently by *boiling* the dyed cloths a few minutes, as is commonly practised at the conclusion of the operation, is a question which I am afraid to answer, as the results of several trials which I have made were not uniform; but if it should be found expedient to employ a *boiling* heat for this purpose, all danger of any harm from it might be avoided, by giving it with *clean* water, in a separate pan, to which the cloths might be removed, after having already imbibed sufficient colour, with only a scalding heat; in this way there would be no danger of increasing the extraction of the yellowish brown colouring matter, or promoting its application either to the cloth or the aluminous basis.

When it is thought desirable to render the madder red brighter than it can be made by alum and tartar only, (as mordants,) some dyers are accustomed to add a small proportion of nitro-muriate of tin to the other mordants, in *preparing* the cloth. But a more beneficial effect would be produced by reserving this nitro-muriate, and employing it with the madder (putting both into the water at the same time) for the dyeing operation; because, the acids, combined with the tin, will, in a considerable degree, obstruct the extraction of the yellowish brown part of the colouring matter; and a similar effect may be produced by employing a little sour bran liquor along with the madder. Sometimes

orchall and Brasil wood are combined with madder, to render its colours more *rosy;* but their effects are not lasting.

Having witnessed the utility of glue, in purifying and brightening the colours of morus tinctoria, and quercitron bark, I tried it with madder, though unsuccessfully; the latter appearing to be destitute of *tannin*, or any matter capable of being separated or precipitated by an animal jelly.

In regard to the application of tin, or rather the solutions of that metal, as a *basis* for the madder red upon wool, I think myself warranted, by numerous experiments, to recommend it, where colours approaching the scarlet from cochineal are wanted, though I do this in opposition to the high authority of MM. Berthollet, (father and son,) who assert, that their multiplied experiments with this mordant have not produced any beneficial effect worthy of notice, in regard to the madder colour, (see Elements, &c. tom. ii. p. 122 and 125;) and I can only account for this assertion, so much at variance with my own ample experience, by supposing, that in all their trials with madder, the nitro-muriate of tin was exclusively employed, (as it has been by the dyers,) to *prepare* the cloth, and wholly omitted in the second or *dyeing* operation with madder; and certainly when so employed, the colour will be but little brightened or improved; though, if a part of this nitro-muriate be reserved and mixed with the water, before the madder is put into it, so that its acidity may obstruct the extraction of the yellowish brown part of the madder colour, a very sensible increase of its vivacity will soon become evident: or, even if the whole of the solution of tin be employed to *prepare* the cloth, a similar effect may be obtained, by mixing a portion of tartar conjointly with madder in the dyeing vessel, as the tartaric acid will be

equally efficacious with the nitro-muriatic for impeding the extraction of the brownish yellow part of the madder colour. And the effect of the little thereof which may be extracted and taken up by the cloth, might be nearly overcome, by adding a very small portion of cochineal to the madder. Sour bran liquor will operate in the same way as tartaric acid, but neither should be employed in excess, least it should reduce or weaken the red colour. Cloth prepared with a solution of tin and tartar, should not be rinced previously to their being dyed, unless the solution has been used to excess.

I have already mentioned (at p. 366 of my first volume) that the madder colour, when dyed upon the basis of tin, had been found, in my experiments, to be extremely durable; and when properly dyed, it certainly is but little inferior in vivacity to that of cochineal, and might, perhaps, be made even to surpass the latter, if the *pure red* part of the root could be *exclusively* applied with the oxide or solution of tin; or if, after being applied conjointly with the brownish yellow part, this last could be separated from the former, by the means employed to purify and enliven the Turkey red, or by any other means which would not injure either the cloth or the colour. For as the Turkey red, though dyed upon the aluminous basis, is, by this purification or separation, rendered nearly equal in vivacity and beauty to the finest cochineal scarlet, which has been dyed on a basis derived from tin, there is reason to conclude, that by a substitution of the latter basis, a colour more excellent even than the best scarlet might be produced with such purification. But, unfortunately, this substitution is impracticable upon either linen or cotton, because there is but little affinity between either of them and the oxide of tin; and when the substitution is made in regard to *wool*, the means by which the madder colour is af-

terwards purified on *cotton*, cannot (as was lately observed) be employed upon wool, without destroying it.

Such is the affinity of madder for wool, that when both are put into water and kept at a scalding heat for one hour, the wool will imbibe a full, though brownish red colour; and broadcloth boiled for half an hour in water moderately acidulated by sulphuric acid, and afterwards dyed, unrinced, with madder, will acquire a better red; which, though less bright and less permanent than that dyed upon the *aluminous* basis, will bear exposure to the sun and air, during two months, without any considerable injury. Cloth treated in the same way with water acidulated by the nitric, muriatic, tartaric, and citric acids, and dyed with madder, took reds of different shades, but of nearly equal permanency. *These effects were to me very unexpected.* Linen and cotton, however, took no colour by the same treatment and means. A strong proof of the greater affinity of some colouring matters for animal than for vegetable substances.

The remarkable effect of madder, in giving its red colour to the bones, but not to the soft parts of animals, with whose food it had been mixed,* appeared to indi-

* Beckman, in his history of inventions (vol. iii.) mentions Lemnius, (a physician in Zealand, where madder had been long cultivated), as being the first writer who had published this fact, and he quotes the following words from the treatise of Lemnius de Miraculis occultis naturæ, printed at Cologne, in 1581, viz. "Erythrodanum seu rubea ossa pecudum sandicino rubentique colore imbuit, si quando herbam virentem depasta sunt, intacta etiam radice, quæ rutila existet; quod etiam in elixis decoctisque; ejus pecoris carnibus perspici potest, et in ovis, quæ rubicunde colore radicis decocto fucantur." Beckman acknowledges, indeed, that this passage does not occur in the first edition of the work, printed in 8vo. in the year 1559, but supposes it to have been contained in the second, which was printed in 1664; and that a knowledge of this fact was thus obtained by Mizaldus, who, in his "Centuriæ

cate a considerable attraction between calcareous earth and the colouring matter of this root, and I was induced by it to employ the former as a basis for the latter, in dyeing both upon wool and cotton; but the effect did not answer my expectation; as neither lime recently burnt, nor the carbonate of it, when mixed with madder in water, produced colours more lively and permanent than madder alone. But broadcloth, boiled in water with lime and sulphuric acid, in such proportions as to neutralize the latter, and afterwards dyed with madder, took a lasting red colour, though not so bright as when dyed upon the aluminous basis. Cotton, however, being treated in the same manner, was but slightly discoloured.

Broadcloth, prepared with a nitrate of lime, and dyed

novem memorabilium, utilium ac jucundorum," printed in 8vo. at Paris, in 1566, states the same fact in *almost the same words*.

It will have been seen in the passage just quoted, that Lemnius mentions this effect upon the bones of animals, as having been produced by their feeding only on the *leaves* without the *roots* of madder; and Beckman says he has proved in his "Experimenta emendandi Rubiæ usum tinctorum," that the *green leaves* of madder contain, and really communicate, a *red dye*.

Though this effect of madder upon the bones of animals had been thus mentioned in the 16th century, by Lemnius and Mizaldus, it was forgotten and become unknown, until the late Mr. John Belcher (a surgeon) happened to dine with a calico printer in Surrey, about the year 1736, and observed that the bones of some pork which made a part of the dinner, were red; when, upon expressing his surprise at the fact, he was told, that the hog from which it was taken, had been fed on bran, after it had been employed in one of the operations of calico printing, and had thereby imbibed the colouring matter of madder roots. Mr. Belcher afterwards ascertained, by adding some powder of madder roots to the food of dunghill fowls, that a similar redness was thereby communicated to their bones; and he gave accounts of his observations and experiments to the Royal Society, which were printed in the Phil. Trans. No. 442, and No. 443, (1736,) and these were followed by others from M. du Hamel du Monceau, in 1740.

with madder, took an orange colour; but cotton treated in the same way, remained almost white. Muriate of lime with madder, produced a brownish red upon wool, which suffered but little by thirty-eight days exposure to the sun and air.

Broadcloth, prepared with sulphate of magnesia, and dyed with madder, took a salmon colour of but little durability. Cotton treated in the same way, remained nearly white.

Broadcloth, boiled with muriate of barytes, and afterwards dyed with madder, took a dull red, of but little durability.

Broadcloth, boiled with a muriate of antimony, and dyed (unrinced) with madder, took a very good and permanent red; less bright, indeed, than that dyed with solutions of tin, but preferable to that commonly dyed upon the aluminous basis.

Broadcloth, treated in the same way with nitro-muriate of cobalt and madder, obtained a reddish brown colour; with nitrate of bismuth and madder, a dark brownish red; with nitro-muriate of zinc, a reddish orange colour; with nitrate of lead, an orange, inclining to the brick colour; and with sulphate, nitrate, and muriate of copper, separately, browns, inclining more or less to yellow.

Iron, dissolved by the sulphuric, nitric, and muriatic acids, and applied severally as a basis to cloth, produced with madder various shades of dark coffee colours, somewhat approaching the violet.

Silk, macerated during twenty-four hours in a diluted muriate, or nitro-muriate of tin, not more than blood-warm, and afterwards dyed, unrinced, with madder in water moderately warm, acquired a lasting red of considerable vivacity; and being macerated in a cold solution of alum, instead of the solution of tin, it obtained

in the same way, from madder, a permanent red, similar to that commonly dyed by the same means on wool or cloth; but as the most lively and beautiful colours are generally required for silk, those of madder are but rarely employed with this substance.

On *Linen* and *Cotton*, the madder colour is eminently useful with the basis of alum; and for dark colours, with that of iron; which, indeed, are the only bases employed in calico printing, as was observed in my first volume; where, (i. e. between pages 266 and 281) I have described the preparation of the acetate of alumine and that of iron, as well as the means and methods of applying them to calico intended to be printed; and I have, moreover, given a concise account of the manner in which the calico, when printed, and afterwards cleansed, is to be dyed with madder; but of this last operation, it may be proper that I should furnish some additional explanations.

Calico, when intended to be printed and dyed with madder, should be first carefully and thoroughly bleached; and even when this has been done, it should be immersed for some time in an alkaline lixivium of proper strength, and (after being rinced) macerated a few hours in water acidulated by sulphuric acid, to dissolve and remove any earthy matters which might otherwise not only degrade the madder red, but fix it on the parts intended to be kept white.

The proportion of madder to be employed must depend upon the extent of surface intended to be coloured by it, and the depth or fulness of the colours desired: when very full dark reds are to be produced, it will be best to employ but *half* of the madder at *once*, and repeat the operation with the other half, in order to avoid that alteration and degradation, which the madder colour suffers, when kept longer than usual, even at a degree of

heat much below the boiling point. And, for this reason, the dyeing should always be stopped as soon as the colours have been sufficiently *raised:* and, I am persuaded, that to obtain the brightest reds with the least discoloration of the *white* parts, it is always advisable that the dyeing liquor should never be made much hotter than the hand can bear; and that the boiling, if it be deemed expedient, should take place afterwards with clean water in a separate pan; which will also remove a part of the discoloration of the white parts. Commonly two or three pounds of madder for each piece of calico are crumbled into the water, and being well mixed therewith, the pieces, tacked together by their ends, are put into the dyeing liquor as soon as it becomes blood-warm, and afterwards turned through it constantly, backwards and forwards over the winch, pressing down those parts of the calico which rise above the surface. It is desirable, that the colouring matter should have applied itself sufficiently within the space of an hour, and then the pieces should be turned out of the liquor immediately, and carried as soon as possible to a stream of running water, and be there well washed, to obviate the *spotting*, to which they would otherwise be liable; and when this has been done, they are to be boiled in water with bran, (which removes a portion of the *brownish* colouring matter,) and afterwards exposed upon the grass, with the well known management and precautions; and this alternate boiling with bran, and exposure on the grass, are to be repeated until all discoloration by the madder has been removed from the parts to which no mordant or basis was applied, and some of the brownish part of the colour also detached from the red parts. The use of bran, for the purpose just mentioned, has been found to be unnecessary in the East Indies, by those who have *there* practised the European

methods of calico printing; exposure to the sun and air, and the application of water, being abundantly sufficient in that climate to produce the desired effect.

When sumach is intended to be employed with madder, it is thought best to apply it first, or separately, at the rate of about one pound of that which is *brightest*, and of the best quality, to each piece of calico, putting it into the water whilst cold, and turning the pieces by the winch, fifteen or twenty minutes through the liquor as soon as it becomes blood-warm, and taking care not to make it hotter than the hand can bear; after which the pieces should be rinced in water with a very little sulphuric acid, and dyed *immediately* with madder, or kept *under water* until dyed, otherwise the sumach, by absorbing oxygene from the atmosphere, will produce a troublesome discoloration of the parts intended to be left white.

It has been found practicable within a few years, to produce from madder upon calicoes, a *rose* or *pink colour*, by employing it with a large proportion of bran, which, by its acidity, hinders, in a great degree, the extraction of the brownish yellow part of the colouring matter of the madder, and its application to the calico; an effect similar to that which I lately mentioned as produced by the acid of tartar, in dyeing wool or woollen cloths. This employment of bran, was lately brought into notice by a journeyman calico printer, named Growse, and the colour obtained by it was called Growse's *pink*. His process (which was cheaply purchased for one hundred guineas, by a subscription among the master calico printers,) was performed by putting into a copper, or dyeing pan, with water, three bushels of bran, and making the liquor boil about five minutes, then suffering it to cool, and adding sixteen pounds of the best crop madder, which, by stirring, is to be well mixed therewith, and in this mixture pieces of calico, previously

impregnated, or printed with *strong* acetate of alumine, and afterwards well cleansed, are to be dyed, by passing or turning them quickly six or eight times backward and forward though the liquor; then rincing and washing them until fit for sale, without either branning or bleaching, as the acid derived from the bran served, in a great degree, to protect the white grounds from discoloration. It is, however, necessary to the success of this operation, that the proportions of bran and madder should be nicely adjusted, for where the former is in *excess*, the colour will be weak, and where it is deficient, the colour will be less rosy, and the white grounds more discoloured.

I have repeatedly found that a similar effect (i. e. that of obviating, in a considerable degree, the discoloration of the white grounds) might be obtained by employing along with madder about one sixth of its weight of the best sumach; but this addition made the red incline more to the orange tint. The leaves and tops of the plant, which I received from Mr. Alderman Prinsep, under the name of *d'howah*, as mentioned in the preceding chapter, produced the like effect of hindering a discoloration of the white grounds, and without any sensible change of the madder red. A solution of glue being put along with madder into the dyeing vessel, manifestly obstructed the combination of the colouring matter with the aluminous basis, so that only a kind of salmon colour was produced.

M. Haussman (now of Longleback, near Colmar,) strongly recommends, in dyeing with madder, the addition of about one fifth or sixth of its weight of either powdered chalk or quick lime, to decompose or counteract a portion of sulphate of magnesia, supposed to be naturally contained in madder. He adds, that it was not until he had removed from Robec, near *Rouen*,

where the water naturally holds *carbonate* of lime (chalk) in solution, that he discovered the error of an opinion which had been entertained by himself and other calico printers in that neighbourhood, who imagined that the superiority of their madder reds, was due *not to this quality* of their water, but to certain *useless* drugs which they employed, and withheld as a great secret: and he asserts, that in all situations where the water does not contain some portion of carbonate of lime, the utility of putting it into the dyeing vessel along with madder, may be rendered manifest, by taking two pieces of calico, printed with *exactly the same mordants*, &c. and dyeing them separately with the same madder, and with no other difference than that of putting chalk into one vessel and not into the other; as the red dyed with the aid of chalk, will be found much brighter and more durable than the other, and more capable of supporting the action of bran, soap, &c. See Ann. de Chimie, tom. x. and lxxvi.

I have in vain tried, with a great variety of means, to produce a *prosubstantive red* from madder. Its colouring matter seems incapable of being fixed upon linen or cotton by any basis, unless the basis be applied *separately* from the colouring matter.

After these observations concerning topical or partial dyeing on calico with madder, I proceed to the application of it *generally*, (and without any reservation of white or other coloured parts,) to linen and cotton, either woven, or only spun into thread or yarn.

Two kinds of *red colour* are dyed from madder upon linen and cotton; one of these is the common madder red, and the other the *Turkey* red, to be treated of in the next article: both are dyed upon the aluminous basis, but with a considerable difference in regard to the auxiliary means and modes of employing them. For the

common madder red, linen or cotton, after being boiled in a weak lixivium of potash or soda, and well rinced and dried, is to be macerated in a decoction of powdered galls, employed after the rate of four ounces to every pound of linen or cotton to be dyed; and being equally impregnated with the soluble matter of the galls, and afterwards dried, the linen or cotton is to be alumed, by soaking it thoroughly in a saturated luke-warm solution of alum, employed also at the rate of four ounces to each pound of linen or cotton; after having previously neutralized the excess of its acidity, by adding to the solution one ounce of soda for every pound of alum: this being done, and the linen or cotton moderately and equally wrung or pressed, it is to be well dried, and afterwards alumed a second time, dissolving for that purpose half as much alum as for the first aluming, and adding to it the residue of the former solution. After this second aluming, the linen or cotton is to be again well dried, and then rinced, to remove any superfluous part of the alum which may not have been united thereto.

By substituting the acetate of alumine (formerly described) for the solution of alum, just mentioned, a more beneficial effect might be obtained; but it would be attended with a considerable increase of expense.

The use of galls, in this operation, will be readily conceived, by recurring to what I have mentioned at p. 263, and 264, of my first volume, concerning the effect of myrobalans, when employed by the Hindoos, in causing a more copious precipitation, and a more intimate union of the earth of alum, in or with the calico which had previously imbibed their astringent matter. That this is the only use of galls so employed, I presume, because I have found, by repeated trials, that when employed with madder in the dyeing operation,

they add nothing to the durability of the colour.* Linen or cotton which has been thus impregnated with the aluminous basis, is to be dyed with the best crop madder, employing about three-fourths of a pound thereof for each pound of the substance to be dyed, with the usual management and precautions; particularly that of raising the heat gradually, so that it may begin to boil in about fifty, or at most, sixty minutes, and taking it out of the dyeing liquor when the boiling has continued but a very few minutes; after which, being slightly rinced, it is to be dyed a second time in the same manner, and with the same quantity of madder. After the second dyeing, followed by the usual rincing and drying, it is commonly thought expedient to macerate the linen or cotton in a luke-warm solution of *soap*, (employing for that purpose about two ounces of the latter to each pound of the former,) in order to give more vivacity to the red colour, and remove any adhering, but uncombined, colouring matter; afterwards rincing and drying, as usual.

Some persons have advised a weak solution of glue to be applied to the cotton, after it has been alumed, as before mentioned, believing that it would operate favourably in uniting the alumine more closely with the

* For every other purpose, except that of decomposing the alum, and increasing the precipitation of alumine, and, perhaps, its closer union with the fibres of cotton, *galls appear to do harm* rather than good with madder, by diminishing the vivacity of its colour, and giving it a brownish tinge, without the smallest increase of its durability; on the contrary, I have observed, that when calico printed with acetate of alumine was divided, and one half dyed with madder only, and the other with madder and galls, the colour of the latter, besides a considerable degradation, was injured by being boiled with soap, and also by being exposed to the weather, *sooner*, and in a degree considerably *greater*, than the half which had been dyed with madder only.

cotton and the tanning principle of the galls, and moreover give animal properties to the cotton. The effect of this application has not, however, appeared to produce any considerable benefit in the several trials which I made with it. By substituting the nitrate of alumine for common alum, a red somewhat brighter was produced; but, perhaps, the difference would hardly compensate for the difference of expense.

Sumach is sometimes employed instead of galls, as a preparation for the madder red, and sometimes both are employed together. It can hardly be necessary for me to mention, that piece-work, when dyed, is made to pass through the dyeing liquor by turning it over the winch; and that thread or yarn in skeins is to be put into the liquor upon sticks.

ARTICLE II.

Rubia Peregrina, Linn. Smyrna or Levant Madder, and its application for dyeing the Turkey Red.

The leaves of this species are perennial, commonly in fours, elliptic, shining, and smooth on the upper surface. It has been found wild in some few parts of England; but for the use of dyers has been all imported, chiefly from Smyrna, Cyprus, and Provence. It is called ali-zary, or lizary by the modern Greeks, and foijoy, or fouoy, by the Arabs. The best is cultivated in Bœotia, along the borders of the Lake Copais, and in the Plain of Thebes. It grows also in large quantities at Kurdar, and other places near Smyrna, as well as at Cyprus, whence, in 1760, M. Bertin, one of the French ministers, procured a large quantity of the seeds, which have since produced all the madder of Provence. Its roots have less parenchyma than those of the Zealand madder; but they afford a colour somewhat brighter, and are, therefore, always preferred in dyeing the Turkey red.

But as the people of the Levant, by whom this species is chiefly cultivated and exported, have not had ingenuity and industry sufficient to improve it like the Zealanders, by pounding and separating the skin and inferior parts of the roots, but have left them in their natural state, (whence they are commonly called *madder roots* in this country,) the dyers of woollen cloths have not been able to produce from them, colours so bright as those obtained from the crop madders;* the finer colouring matter of the former being degraded by that of their skins and smaller roots; an inconvenience which is overcome by the dyers of Turkey red, in the last part of their process, as will hereafter be explained. The Levant dyers never employ the fresh gathered roots.

According to the best information which I have been able to obtain, the complicated process by which the *Turkey red* can *alone* be dyed, was many ages ago practised, and perhaps invented, by the inhabitants of Malabar and Coromandel; but with this difference, that instead of *madder*, they employed the roots of the *oldenlandia umbellata*, which will fall under our particular notice in the next chapter. From India the knowledge and practice of dyeing this admirable colour, seems to have been carried to Persia, Armenia, Syria, and Greece, and, after a long interval, to France, in consequence of the accounts transmitted, at different times, by the ambassadors of that nation at Constantinople, of the means and methods employed to dye this red, particularly at *Andrinople*, and of the instructions which, on the faith of those accounts, the French government published, in 1765, under the title of "Memoire contenant le pro-

* Very recently, and since the above was written, mills have been erected in this country, to give the madder roots the same preparation as that of Zealand.

cèdé de la Teinture du coton rouge incarnat *d'Andrinople* sur le coton filé." By this mode of introduction, the colour under consideration obtained, in France, the name of *rouge d'Andrinople*, and in Great Britain that of *Turkey red.*

The instructions, so published, were first carried into practice chiefly at or near Rouen, in Normandy; but for a considerable time they were attended by numerous failures and disappointments; though at present the Turkey red, from various improvements suggested by observation and experience, is supposed to be dyed in that part of France even more permanently, and with greater lustre, than in Greece or any part of the Ottoman empire, or, I may probably add, of Europe.

In the year 1790, M. Pierre Jacques Papillon, who after having been employed in dyeing the Turkey red in France, had practised it successfully at Glasgow, received a premium from the Commissioners and Trustees for Manufacturers in Scotland, in consideration of his communicating to Dr. Black, then Professor of Chemistry at Edinburgh, a description of his process; though, by agreement, it was to be kept a *secret* during a term of years, for the use of M. Papillon exclusively; and that term having expired, and the process having been published, I shall subjoin an account of the several operations of which it consisted, with remarks *upon each*, intended principally to explain its difference, where any occurs, with the correspondent operations in the two processes generally practised at Rouen, as they have been very lately published, by M. Vitalis, "Docteur des Sciences de l'Universite Imperiale; Professeur des Sciences Physiques au Lycée de Rouen, &c." in his "Manuel du Teinturier sur fil et sur Coton filé."*

* Until within a few years, the Turkey red was exclusively dyed upon cotton spun into yarn, but not woven: though, since Mr. Ark-

An account of the Process for dyeing Turkey Red, *as practised by M. Pierre Jacques Papillon, viz.*

Step 1, *or Cleansing Operation.*

For 100lbs. of cotton take
100lbs. of Alicante barilla,
20lbs. of pearl ashes,
100lbs. of quick lime.

Mix the barilla with soft water in a deep tub, having a small hole near its bottom, which is to be stopped at first with a peg, but covered within by a cloth supported by two bricks, in order that the ashes may be hindered from either running through the hole, or choking it, while the *lye* filters through it. Under this tub, another is to be placed to receive the lye; and pure water is to be repeatedly passed through the first tub, to form lyes of different strength, which are to be kept separate until their strength has been examined. The strongest required for use, must swim or float an egg, and is called the lye of six degrees of the French hydrometer, or "peseliqueur." The weaker are afterwards brought to this strength, by passing them through fresh barilla; but a certain quantity of the weak, which is to mark

wright's invention, (by which, as Mr. Wilson observes, "the cotton wool is carded and drawn forward lengthway of the harle, or filaments," and being so spun,) the thread or yarn is made much stronger, and also much more equal, and muslins woven from it, may with care be made to receive the Turkey red dye, and be even variegated by a reservation of *white* spots, &c. by passing the muslin through cylinders after it has been macerated in the oleaginous and other steeps, (in order that the latter may be equally expressed, as is done with other piece-work which has imbibed only a single mordant,) and finally, when the muslin has been dried, and previous to the dyeing operation, printing a strong *reserve* of oxalic or citric acid upon the parts intended to be preserved *white*.

two degrees of the above hydrometer, must be reserved for dissolving the oil, the gum, and the salt, which are used in subsequent parts of the process. The lye of two degrees is called the weak barilla liquor, the other is called the strong.

Dissolve the pearl ashes in ten pails, (containing four gallons each,) of soft water, and the lime in fourteen pails.

Let all the liquors stand until they become quite clear, and then mix ten pails of each.

Boil the cotton in the mixture five hours, then wash it in running water, and dry it.

Remark.—At Rouen two courses of operations are practised to produce the Turkey red; one is called the *grey* course, (la marche en gris,) and the other the *yellow* course, (la marche en jaune). In the former, the cotton, after being alumed, receives no more oil, but goes to the dyeing vessel, retaining the *grey* colour, which naturally results from its being impregnated with alum and galls in combination. But in the yellow course, the cotton, after being alumed, is again immersed in the oleaginous mixtures or steeps, to be mentioned hereafter, by which it acquires a yellow colour. The *grey* course may consist either of fifteen steeps, or of nineteen; and the yellow of twenty. The first of these courses has most similitude to that of M. Papillon, and it is this which I shall principally compare with the latter; occasionally noticing any peculiarity in the yellow course.

At Rouen the first, or cleansing operation (called decrusage) is performed with a very weak lye of soda, of only one degree of the hydrometer, pese-liqueur or aréometré of Beaumé, employing 150 gallons to 100lbs. of cotton, which is to be boiled therein six hours, then drained, well rinced in running water, and afterwards

dried. This operation is intended to *free* the cotton from all impure or extraneous matters; but not to produce effects like those of bleaching by exposure upon the grass, which it was, until lately, believed would lessen the durability of the colours to be subsequently dyed.

Step 2.—Bain bis, or Grey Steep.

Take a sufficient quantity (ten pails) of the strong barilla water in a tub, and dissolve or dilute in it two pails-full of sheep's dung; then pour into it two quart bottles of oil of vitriol, one pound of gum arabic, and one pound of sal ammoniac, both previously dissolved in a sufficient quantity of weak barilla water; and, lastly, twenty-five pounds of olive oil, which has been previously dissolved, or well mixed, with two pails of the weak barilla water.

The materials of this steep being mixed, tramp or tread down the cotton therein, until it is well soaked: let it steep twenty-four hours, then wring it hard and dry it.

Steep it again twenty-four hours, and again wring and dry it.

Steep it a third time twenty-four hours, after which, wring and dry it; and lastly, wash it well and dry it.

Remark.—The steep here prescribed, contains three ingredients not employed, so far as I can recollect, by any other person; and one of these, I mean the sulphuric acid, seems to indicate a want of chemical knowledge in M. Papillon, because, by neutralizing the soda, it must obstruct the effect which the latter is intended to produce, (i. e. that of rendering the oil miscible with water,) or at least render a greater proportion of it necessary, in order to obtain that effect. In regard to the other two of these ingredients, viz. the gum and sal ammoniac, I shall only observe of the former, that the

quantity is by much too small to produce any considerable effect, either good or bad, without offering any opinion of the latter; because I am unable to form even a conjecture, respecting the purpose which it may have been intended to answer.

Did M. Papillon wish, by these additions, to give to his process some appearance of novelty or *peculiarity* which might render it more deserving of a reward?

At Rouen, the *bain bis* is prepared by steeping twenty-five or thirty pounds of sheep's dung several days in a lye of soda, marking four degrees, which is to be afterwards diluted until it amounts to forty gallons; and the dung being squeezed and broken by hands, is afterward made to pass with the liquor through the bottom of a copper pan, provided with numerous small holes or perforations, into a tub containing twelve pounds and one half of fat oil, (huile grasse), and in this the oil and dung are, by sufficient stirring, to be well mixed with the lye, and with each other; and in this mixture, which contains but *half* the quantity of oil prescribed by M. Papillon, the cotton (i. e. 100lbs.) is to be steeped, &c. as directed by the latter.

It is highly important after this, and each of the succeeding operations, that the cotton should be thoroughly and completely dried, by a stove heat, that of the open air in this climate not being sufficient, even in summer.

Step 3.—*The White Steep.*

This part of the process is precisely the same with the last in every particular, except that the sheep's dung is omitted in the composition of the steep.

Remark.—At Rouen this steep is prepared by mixing thirty-eight gallons of lye of soda with ten pounds of olive oil, (huile grasse,) and stirring them until the mixture becomes uniformly milky; which it will do

without much difficulty, and remain so without any separation of the oil, if the quality of the latter be suited to this use; this they add to what may have been left of the former steep, and after mixing them properly, they impregnate the cotton therewith by the usual treatment; drying it after an interval of twelve hours, first in the open air, and afterwards by a stove heat. This steeping and subsequent drying must be repeated once, twice, or three times, according to circumstances to be mentioned hereafter.

Between this *white* steep and the following *gall* steep, it is the practice at Rouen to employ three salt steeps, and one cleansing operation.

In the first, (called *premier sel*,) twenty-four gallons of the lye of soda, marking two and a half degrees, are mixed in a tub, with the remnant of the white steep, and with this, the cotton is impregnated and dried, as in the former operations.

In the next, (called *seconde sel*,) the remnant of the last steep is mixed with twenty-four gallons of the lye of soda, marking three degrees, and the cotton steeped therein, and dried as before.

In the third, (called *troisieme sel*,) the remnant of the preceding steep is mixed with twenty-four gallons of the lye of soda, marking three and a half degrees, and with this the cotton is to be impregnated and dried as before. The residuum of this steep, called *sikiou*, is preserved to be used in the brightening operation.

In the cleansing operation, called *degraissage*, the cotton is steeped one hour in luke-warm water, then wrung by hands, and afterwards washed in a stream of water, to remove any superfluous or uncombined oil, which, as is supposed, might obstruct the *equal* application and *uniform* effect of the following gall steep, and thereby render the colour when dyed unequal. After being so

washed, the cotton is to be dried, first in the open air, and afterwards by a stove heat.

Step 4.—Gall Steep.

Boil twenty-five pounds of galls, bruised, in ten pails of river water, until four or five are boiled away; strain the liquor into a tub, and pour cold water on the galls in the strainer, to wash out of them all their tincture.

As soon as the liquor is become milk-warm, dip the cotton into it hank by hank, handling it carefully all the time, and let it steep twenty-four hours; then wring it carefully and equally, and dry it well without washing.

Remark.—This constitutes the eighth operation in the grey course at Rouen, where, as well as in M. Papillon's process, *galls in sorts* seem to be now employed, though it was formerly thought by the dyers of Turkey red, (as several of them assured me,) that only the *white* galls, or those from which, at maturity, the insects had made their escape, were fit for this purpose; the others being supposed to give an injurious brown stain to the cotton. But, probably, it has been since found, that this stain is removed without any trouble by the subsequent *brightening* operation. At Rouen the cotton, as soon as it has sufficiently imbibed the soluble matter of the galls, and been very moderately wrung, is spread as expeditiously as possible in the open air, if the weather be dry, or if not, under cover; but the drying is always finished by a stove heat.

Step 5.—First Alum Steep.

Dissolve twenty-five pounds of Roman alum in fourteen pails of warm water, without making it boil; skim the liquor well, and add two pails of strong barilla water, and then let it cool until it be luke-warm. Dip your cotton, and handle it hank by hank, and let it steep

twenty-four hours; wring it equally, and dry it well without washing.

Remark.—At Rouen thirty or thirty-five pounds of the purest alum are commonly employed for this steep, with *only seven pails* of hot water; adding, when the alum has been dissolved, *two gallons only* of the lixivium, or lye, of soda, marking four degrees. But when these proportions are employed, the cotton is not subjected to a second steep with alum, as directed in M. Papillon's sixth step.

Sometimes, however, at Rouen, two steeps with the aluminous mordants are employed, and in that case, twenty pounds of alum are dissolved for the first, and fifteen pounds for the second; leaving an interval of two days between them, during which the cotton should retain its moisture, after being slightly wrung from the first steep: it is, however, to be well dried before it goes into the second.

Step 6.—*Second Alum Steep.*

Is performed in every particular like the last; but when the cotton is dry, steep it six hours in the river, and then wash and dry it again.

Remark.—The explanation subjoined to the preceding *step* will suffice for this.

Step 7.—*Dyeing Steep.*

The cotton is dyed in parcels of about ten pounds at once; for which take about two gallons and a half of *ox blood*,* and mix it in the copper, with twenty-eight pails

* Blood was probably first employed in this way with madder, from an expectation that the *red* colour of the former would augment that of the latter; though this must have been a fallacious expectation, as the red globules are not only incapable of being fixed, but are soon rendered almost black in less than a boiling heat; but

of milk-warm water, which are to be well stirred, then add twenty-five pounds of madder, and stir the whole well together; then having beforehand put the ten pounds of cotton on sticks, dip it into the liquor, and move and turn it constantly one hour, during which gradually increase the heat, so that the liquor may begin to boil at the end of the hour. Then sink the cotton and boil it gently one hour longer, and lastly, wash and dry it.

Take out so much of the boiling liquor as will leave the remainder only milk-warm, when mixed with as much fresh water as may be required to fill the copper again, and then proceed to make up a dyeing liquor, as before, for the next ten pounds of cotton; and so proceed in succession with the whole.

Remark.—At Rouen the cotton is dyed in parcels of twenty-five pounds each; and the dyeing vessel is of a quadrangular form, containing about 100 gallons of liquor. One quart of ox blood is employed for each pound of cotton, with two pounds of Provence madder, or one pound of the latter with one of Smyrna madder. Some persons, however, think it best to effect the dyeing by two separate operations, employing half of the before-mentioned proportion of madder for one dyeing, and half for the other; but always taking care not to dry the cotton between the first and second dyeings. There are, moreover, some at Rouen who give cotton another alum steep between these dyeing operations, employing

I am persuaded, notwithstanding, that this employment of blood is beneficial, by affording something which contributes to fix the madder colour, though the particular part of it which produces this effect has not been ascertained. It is thus that, under the impulse of error, we sometimes stumble upon useful truths: an ignis fatuus may lead the benighted wanderer into a *ditch*, or it may conduct him to an hospitable mansion.

for that purpose half as much alum as was used for the first steep; and afterwards washing, &c. as usual.

Step 8.—*The Fixing Steep.*

Mix equal parts of the grey steep liquor, and of the white steep liquor, taking five or six pails of each. Tread down the cotton into this mixture, and let it steep six hours, then wring it moderately and equally, and dry it without washing.

Remark.—For this steep they employ at Rouen the sikiou, mentioned in my remark upon the third step; but the application of it is considered as a part of the following step, or operation.

Step 9.—*Brightening Steep.*

Ten pounds of white soap must be dissolved carefully and completely in sixteen or eighteen pails of warm water; because if any little bits of the soap remain undissolved, they will make spots in the cotton. Add to this, four pails of strong barilla water, and stir it well. Sink the cotton in this liquor, keeping it down with cross sticks, and cover it up; boil it gently two hours, when, being washed and dried, it will be finished.

Remark.—This constitutes the 14th operation in the first set of *grey courses* at Rouen; where, after having macerated the cotton with the sikiou, as just mentioned, they *boil* it five or six hours with six or eight pounds of white soap, previously dissolved in one hundred and forty-five gallons of water, and in a vessel covered at the top, so as to leave only a very small opening for the necessary escape of the steam, which might otherwise occasion an explosion. The effect of this ebullition with soap is to dissolve and separate from the cotton all the yellowish brown part of the madder colour, which may have been applied to it in the dyeing operation; and by

this separation to change the colour from the dull brownish red, which it would otherwise retain, to a bright lively colour, nearly equal to that of the finest cochineal scarlet. It is only by the *singular* degree of fixity which the *pure red* part of the madder colour acquires, in consequence of the operations just described, that this beautiful red can be obtained; for though the reds given from madder in calico printing, are sufficiently durable for all common uses, they are not fixed sufficiently to bear without injury, that extent of boiling with soap, which is necessary to separate the yellowish brown part of the colour, and produce the pure *vivid red*, which results from the operations under consideration. Such, indeed, is the stability of the Turkey red, when well dyed, that some of the persons employed in dyeing it, have assured me that their colours would sustain boiling with soap for the space of thirty-six hours without injury.*

In addition to the steps or operations prescribed by M. Papillon, they employ another at Rouen, called *ro-*

* The preceding operations, agree very nearly with those practised at Thessaly and in other parts of Greece, as described in Baujour's Commerce of Greece, (p. 180, and seq.) and in the Memoir of M. Felix, (Ann. de Chimie, tom. xxxi. p. 195, &c.) though the cleansing is there performed by a lixivium of wood-ashes and soda, made caustic by lime. The grey steep in Greece consists of a lixivium of soda combined with sheep's dung, and with the fluid matter of the second cavity of their stomachs, or those of other ruminating animals, and olive oil; but this is applied at four or five several times, drying between them, and those repetitions of the grey steep supply the *place* of the *white*. After galling in the usual manner, the alum steep is applied *twice* with an interval of two days, and in this steep the solution of alum is partly neutralized by soda. The dyeing is performed with the madder of the Levant, mixed with sheep's blood: after which the brightening operation, or *avivage*, is effected, by boiling the dyed cotton with a weak lixivium of soda.

sage; which is intended to make the *red* incline more to the *rose* colour, and at the same time to increase its vivacity.

For this operation, with the former quantity (100lbs.) of cotton, they dissolve in one hundred and forty-five gallons of water, sixteen or eighteen pounds of white soap; and as soon as the liquor begins to boil, they add to it from one pound and a half, to two pounds of the crystallized muriate of tin, (mentioned at p. 382, of my first volume,) previously dissolved in two quarts of water, and mixed with eight ounces of single aqua-fortis; and having equally dispersed this mixture through the boiling solution of soap, by stirring, &c., the cotton is put into it, and boiled with the same precautions as in the brightening operation, until the desired effect has been obtained, which is to be discovered by frequent examinations. Care must be taken not to employ more nitric acid, or aqua-fortis, than the quantity here mentioned, least it should decompose the soap, and cause the oil to separate, and rise to the surface of the liquor.

M. Vitalis supposes, that a metallic soap is formed in this operation; the oxide of tin being, as he thinks, dissolved by the soda.

That a solution of tin, employed in this way, should add something to the vivacity of the colour, is very probable from what I have seen of its effects upon the madder red. But I am convinced that it can add nothing to its fixity on cotton, unless the nature of the latter should have been greatly changed by the impregnation which it receives by the operations recently described. M. Vitalis adds, however, (p. 98,) as a discovery of his own, and one which, as he says, has been successfully tried upon a large scale, that an acid sulphate of potash, employed with soap in the proportion of two or three pounds of the former, to one hundred pounds of cotton,

will answer all the purposes of the muriate of tin, giving a particular and very pleasing shade to the Turkey red.

In regard to the second of the grey courses employed at Rouen, I must observe, that it differs from the first, by having two additional repetitions of the grey steep, (with dung,) and four of the white steep, (after the first,) with two gall and two alum steeps.

In the *yellow* courses, after the first gall and the first alum steeps, two of the *white* are interposed, with two of the *salt* steeps (sel) in addition to the like number given before the first galling; and these are succeeded by a second gall steep, and a second maceration in a saturated solution of alum; after which, the cotton, being well dried and then rinced, is dyed with Provence madder alone, in the proportion of two pounds and a half of the latter to each pound of cotton, or with a like quantity of Provence and Smyrna madders mixed in the proportion of one-third of the latter, to two-thirds of the former. This *yellow* course, as may be supposed, is intended to produce the richest and most durable colour.

M. Vitalis asserts, (p. 100,) that it is impossible to produce a fine and permanent Turkey red, without employing in the different operations, forty pounds of oil for each hundred pounds of cotton; and that the stove heat for drying, ought not to be less than 55 degrees of Reaumur's scale, which is equal to 158 of Fahrenheit's.

To this account of the different courses and operations, employed to produce the colour in question, I shall subjoin an extract of certain observations respecting it, published in the 26th volume of the Ann. de Chimie, by M. Chaptal, (late minister of the interior of France,) which are the more valuable, as being the result of a great portion of chemical science, added to an

extensive *practical* acquaintance with these operations, and their effects.*

"It is known," says M. Chaptal, "that cotton does not take the madder red permanently, unless it has been sufficiently impregnated with oil. This preliminary preparation is given to cotton by a cold saponaceous liquor, formed by a combination of oil, with a weak lixivium of soda. All kinds of soda, and of oil, however, cannot be employed for this purpose. In order that the soda may produce suitable effects, it must be *caustic*, and contain but little muriate; and this causticity must be produced by calcination, and not by an admixture of lime, which gives a brownish tinge to the red.

"The carbonate of soda, and soda mixed with a considerable proportion of muriate, will combine but imperfectly with oil; and, therefore, soda either long prepared, or impure, is unfit for this purpose.

"The choice of the oil is of as much importance as that of the soda. The former, to be good, should unite very perfectly with the lye, or lixivium of the soda, and remain in a permanent state of combination. The oil fittest for this dye is not fine oil, but that which contains a large portion of the extractive principle.† The

* See also, l'Art de la Teinture du Coton en Rouge, &c., par M. J. A. Chaptal, Membre, et Trésorier du Sénat, Grand Officier de la Legion d'Honneur, &c. &c. 8vo.

† The oil employed by the dyers of Turkey red in Great Britain, is imported chiefly from Italy under the name of Gallipoli oil. After the finest olive oil which rises to the surface has been drawn off, the heavier, which is combined with a considerable portion of mucilage, is separated from the dregs at the bottom of the cistern, and this constitutes the Gallipoli oil. Its *mucilaginous* part, enables the *oleaginous* to unite, and form a mixture of a milky appearance, with a *weak* lixivium of soda, which the purer oil would not do. If when this mixture is formed, it preserves its milky appearance 24

former does not preserve its state of combination with the soda, without such a degree of strength in the lye as would prove injurious to the subsequent operations. The latter forms a thicker and more durable combination, and requires only a weak lye of one or two degrees.

"The necessity of producing a perfect and intimate combination of the oil and the lye of soda, will be readily perceived, by considering that the lye is only employed to *divide*, dilute, and convey the oil in an equal manner to all the parts of the cotton, and, therefore, if the oil be not well mixed, the cotton made to pass through this mixture will take the oil unequally, and the colour be but badly united. Hence it happens that the workman places the whole secret of a well united and strong colour, in the choice of good oil and proper soda: and, consequently, the oil ought to be rather in excess than in a state of absolute saturation, for in the

hours without any separation or collection of oil in globules upon the surface, it is deemed suitable for the Turkey red dyers. In the East Indies, whence the Turkey red was derived, the oil of sesamum, (obtained from the seeds of the vanglo plant,) is commonly employed for this purpose, (as, indeed, it is by the Turks,) and when this is wanting, they substitute hog's lard, as will be seen in my next chapter; and, indeed the Abbé Mazeas has asserted, in a "Memoire" printed among those of the Royal Academy of Sciences at Paris, (viz. those of the "Sçavans Etrangers," tom. iv.) that he had produced better effects in this way with hog's lard, than it was possible for him to do by any other greasy or oily matter; and, we are informed by Professor Pallas, that the Armenians, who have been, by the troubles in Persia, driven to Astracan, do there successfully employ fish oil to dye the Turkey red. It seems, therefore, that *animal* oil, or fat, will answer the purpose in question as well as the vegetable. The circumstance of most importance seems to be, that of not employing those oils which are called *drying* oils, such as that of lintseed, which is said to blacken the colour in some degree, probably by absorbing oxygene; and it seems to be this property, which has caused it to be employed to improve the black colour dyed upon cotton.

latter case it would abandon the cotton in the subsequent washings, or rincings, without benefiting the colour.

"When the cotton has been properly impregnated with oil, it is subjected to the operation of galling. The use of the gall-nuts is attended with several advantages: 1st. The acid which they contain decomposes the saponaceous liquor with which the cotton has been impregnated, and fixes the oil on the stuff. 2d. The character of *animalization* which the galls possess, and *impart*, predisposes the cotton to receive the colouring matter. 3d. The astringent principle unites with the oil, and forms with it a compound which darkens as it dries, which is not very soluble in water, and which has the greatest affinity with the colouring principle of the madder. The dyer may acquire a competent knowledge of this last combination, and study its properties, by mixing a decoction of gall-nuts with a solution of soap.

"It follows from these principles: 1st. That the place of the gall-nuts cannot be supplied by any other astringent, let the quantity employed be what it may. 2d. That the decoction of galls ought to be employed when warm, that the decomposition may be speedy and perfect. 3d. That the galled cotton ought to be speedily dried, in order to prevent its assuming a dark colour, which would injure the brightness of the red intended to be given to it. 4th. That dry weather ought to be chosen for the process of galling, because in moist weather the astringent principle communicates a dark colour, and dries slowly. 5th. That the cotton ought to be pressed together with the greatest care, in order that the decomposition may be effected in an equal manner, at every point of the surface. 6th. That a proportion ought to be established between the gall-nuts and the soap; if the former predominates, the colour

will be dark, if the latter, a portion of the oil, not combined with the astringent principle, will escape by the washings, and the colour will be poor.

"The third mordant employed in dyeing cotton red, is the sulphate of alumine (alum). This substance not only has of itself, the property of heightening the red of madder, but it contributes also by its decomposition, and the fixation of its alumine, to give solidity to the colour. To judge of the effects of alum in dyeing cotton, it will be sufficient to mix a decoction of gall-nuts with a solution of alum. The mixture becomes immediately turbid, and a greyish precipitate is soon formed, which, when dried, will prove to be insoluble in water and the alkalies.

"Every thing that takes place in this experiment of the laboratory, may be observed in the process of aluming for dyeing. Cotton, when galled and plunged in a solution of the sulphate or acetite of alumine, immediately changes its colour and becomes grey; the bath presents no precipitate, because the operation takes place in the tissue of the cloth itself, where the production remains fixed. But if the galled cotton be passed through a solution of alum that is too warm, a portion of the galls will escape from the tissue of the stuff, and a decomposition of the alum will take place in the bath itself, which will diminish the proportion of the mordant, and impoverish the colour.

"We have here, therefore, a combination of three principles (oil, the astringent principle, and alumine) which serve as a mordant for the red dye of madder. Each of them employed separately, produces neither the same fixation, nor the same lustre in the colour.

"This mordant, undoubtedly, is the most complex of any which is known in dyeing; and it presents to chemists a sort of combination eminently deserving of their

utmost attention. It is only from a great degree of precision in this combination, and a great portion of judgment in the artist who produces it, that a beautiful colour can be expected; but though it be possible for him to conduct himself without error, through the labyrinth of these numerous operations, by taking the clue of experiment as his guide, he will find it very difficult to simplify his progress, or bring it much nearer to perfection. It is only by reasoning on his operations, and calculating the result as well as the principle of each, that he can hope to become master of his processes, to correct their faults, and to obtain invariable products. Without this, the practice of the most experienced artist, will afford nothing in his hands, but the discouraging alternative of success and disappointment. I wished, therefore, in this short analysis of the process for dyeing Turkey red, which is the most complicated of all, to give an instance of what chemistry can do in the arts, when its principles are properly applied. I will venture to assert, that the most uninformed workman will here find the principle of his art, and the rule of his conduct."

As I had long accustomed myself to respect the opinions of M. Chaptal, who, by being extensively engaged in dyeing the Turkey red, had obtained very superior opportunities of discovering the truth respecting it, and as his reasonings concerning the effects of the various applications under consideration, were so well calculated to produce conviction, I, without much hesitation, some years ago, adopted his general conclusion, that *the result of all the operations for dyeing this colour, is that of producing a combination of three substances, alumine, oil, and the astringent principle* (" *l'alumine, l'huile, et le principe astringent*,") *and thus forming a mordant, which* (*in his opinion*) *is the only one capable*

of rigorously fixing the madder colour. See his Memoir dans le Recueil des Memoires de l'Institut, vol. ii.

But after having adopted this conclusion, I was forced to believe, that a suitable, and perhaps more efficacious, combination of these *three* substances might be made with greater simplicity, expedition, and benefit, than by the complicated, and, in many respects, incongruous mixtures and operations commonly employed for that purpose; and in this belief, I undertook, and was occupied, during almost all the year 1809, by a series of experiments, in which oily, or saponaceous mixtures, decoctions of galls, and solutions of alumine, were applied to cotton, with every possible inversion or change in the order of their successive applications, and with so many variations in their absolute as well as relative proportions, and in all the circumstances likely to influence their effects, that, if it had been possible, by these means *alone*, to enable cotton to acquire from madder a colour equal to the Turkey red, it must, as I confidently believe, have been produced. The best results, however, of all my experiments were only reds, not considerably better than those frequently given with madder by calico printers, in regard to their power of sustaining the action of soap, alkalies, and the air; though they were able a *little* longer to resist the force of a diluted nitric acid; a small immunity which was probably derived from the combination of oil and the astringent matter of the galls with the alumine, which last is the only basis of the madder red given to printed calico.

Since these failures, and *in consequence of them*, I have found it necessary to suppose, that some matter, not to be obtained from oil, galls, and alum, is necessary to the stability of the Turkey red; and this matter I have suspected to exist in the dung and the intestinal liquor of ruminating animals, or in that of their second stomachs,

of which no use was made in my experiments, because they were not included by M. Chaptal among the things *required* to produce the colour in question, and because M. Le Pileur d'Apligny,* M. Felix,† and others, had declared them to be of no use towards fixing the Turkey red.‡

At page 270 of my first volume, after mentioning the use made by calico printers, of *cow-dung*, to remove the superfluous part of their aluminous mordant, I have said there was "reason to believe that the cow-dung, by the gastric juices, gelatine and albumen, which it contains, afforded a very beneficial impregnation to the printed calico, of *some animal matter*, which, combining with the mordant, serves to bind it more strongly to the cotton, and afterwards to increase its attraction for the colouring matter, like some of the animal impregnations which are so necessary for the Turkey red." This opinion had been adopted, after all my endeavours to produce the colour in question from oil, galls, and alum, had proved useless; and when I had formed the opinion which I retain (and which by his "Memoire, presenté a l'Institut National" de France, appears also to be entertained by M. Vitalis,) that the gelatine contained in the dung of ruminating animals, or

* See Art de la Teinture des fils et Etoffes de Coton.

† See also his "Memoire sur la Teinture, et le Commerce du Coton filé Rouge, de la Grece," in the Ann. de Chimie, tom. xxx.

‡ It must also be observed, that I did not employ either sheep's or ox's blood with the madder, in the dyeing part of these experiments; for though M. Chaptal believes that it may give more *vivacity* to the colour, he does not include it among the substances contributing to its *fixity*, and I had it principally in view, to ascertain the matters *necessary to produce that effect*. Had I employed, and succeeded by employing, *blood*, my purpose would have been frustrated by reason of the *various matters* of which it consists, and which would have left me in the same uncertainty as before.

the albumen which it also affords *in a much larger proportion*, or some other matter, derived from it, and probably from their blood, is essentially necessary to produce that fixity, as well as beauty of colour, for which the Turkey red is so much admired, though at present, we only know with certainty of this matter, and this colour, that both may be communicated by the successive applications and operations which have been recently described, but of the *particular* effect of either, we are in a great degree ignorant.

The first operation ("decreusage") in each of the several courses, is intended, and may be deemed sufficient, to remove from the cotton, every thing which could obstruct either the application or combination of the several matters required to produce the Turkey red; and, therefore, the *end of all the subsequent operations ought to be, that of adding*, or promoting the combination of something, required to enable the cotton to imbibe and permanently retain the colouring matter of the madder; but several of these operations must, as far as I can judge, produce a different effect, by *dissolving* and *removing* a considerable part of the matters antecedently applied by the other preceding operations: such, for instance, must be the effect of the *salt* steeps, consisting of solutions of soda, employed subsequently to those containing the dung, the saponaceous mixtures, and the decoction of galls; and, therefore, unless these latter steeps were either hurtful, or excessive in their strength or quantities, it must be inferred, that the salt steeps would do harm by diminishing, at least, the benefits to be derived from the previous application of the dung, oil, and galls.

M. Chaptal supposes, as others, when reasoning on this subject, have done, that the only good purpose to be answered by combining soda with the oil, (necessary

for the Turkey red,) is that of rendering the latter miscible with water. But is it necessary that the oil should be mixed with water? If it be employed in sufficient quantity it will, while unmixed, *penetrate* the cotton as *thoroughly* and *equally*, as it does when formed into the saponaceous mixture, and, perhaps, more so; and though I once imagined that cotton, which had imbibed pure olive oil, so as to be saturated therewith, might not afterwards freely admit the astringent matter of galls, or the alumine; or that the oil would afterwards obstruct the application of the colouring matter, in the dyeing process, I have found, by repeated experiments, that no such effect is produced by oil so imbibed; but, on the contrary, that oil attracts and unites with the colouring matter of madder, and that cotton, even when the aluminous mordant has been first applied to it in spots, as by calico printing, may be soaked repeatedly in pure olive oil, and being merely squeezed to separate the superfluous part of the latter, it may be put into a dyeing vessel with madder, and there made to receive the colour most freely and copiously *upon the spots* or parts which had been previously alumed; the attraction of the aluminous basis for the madder colours, being rather promoted than lessened by this *interposition* of the oil; though it must be confessed that the latter did not appear to render the colour much more durable than it would otherwise have been. This being the case, the only reasonable motive for mixing the oil with water, must depend upon a belief, that while unmixed it cannot be applied equally and thoroughly, without being applied in excess; but in opposition to this belief, I may adduce the practice of the Armenians, at Astracan, who, for their red dye, as we are informed by professor Pallas, soak their cotton in pure unmixed *fish oil*, during seven successive nights, taking it out of the oil and ex-

posing it to the sun and air, during each succeeding day; and then, after rincing it only in running water, immerse the cotton in a steep or decoction of galls and the leaves of sumach; then dry, and afterwards alum it, for the subsequent operation of dyeing with madder.* These facts seem at least to render it probable, that the union of an alkali with oil is not necessary, to *obviate the application of it too copiously;* and that if it be intended to remain in combination with the cotton, such an union, by rendering it miscible with water, must counteract that intention, and make the oil liable to be, in a great degree, removed by some, at least, of the subsequent steeps.

That so much of uncertainty and obscurity should still prevail, in regard to this very estimable and extraordinary colour, is to me a matter of deep regret; and if my life should be prolonged a few years, and I *should be enabled to choose my occupations*, no endeavours of mine will be wanting to elucidate the subject; being persuaded, that by doing so, I may not only enable the Turkey red dyers to produce their colour at much less expense, but that this elucidation will throw a most beneficial light upon other parts of the art, and afford means also of adding to the beauty and stability of many other colours.

* M. Bourdier, a physician, who had resided eleven years at Pondicherry and other places along the coast of Coromandel, asserts, that at *Masulipatam and Pulicat*, (where the reds are excellent,) the cotton, after being dyed, is soaked either in the oil of sesamum, or in melted hog's lard; and the oil being afterwards pressed as much as it can be from the cotton, the latter is exposed to the sun and air for some days; that this operation is repeated three times, after which the cotton is well washed. He says, that hogs' lard is preferred to oil for this use, and that the fine red handkerchiefs of Pulicat and Masulipatam have all been so treated. See "Mem. Geographiques, Physiques, &c. sur l'Asie, l'Afrique, et l'Amerique," tom. 1. pp. 207, 208.

I have thought it expedient in this manner to endeavour to correct an error, which has lately become prevalent, I mean that of supposing that the true principle or cause of the fixity of the Turkey red had been discovered or ascertained; as this error must necessarily obstruct the attainment of truth, by leaving no motive for subsequent inquiries, or experiments, on this subject.

ARTICLE III.

Rubia Manjit'h, or Manjit'ha, of the Hindoos; and Majisht'ha of the Sanscrit.

This species of madder was imported, though I believe in a small quantity, by the French East India Company, about the year 1760, under the name *mongister;* and sometime afterwards, by the English East India Company, under the name of *majesto* root. More recently the importations into Great Britain have increased, and it has acquired, in the Company's sale catalogues, the names of *manjit*, and *mungeet*. It has appeared to consist of the *stem* of the plant, commonly six, eight, or more feet in length, and of twice the diameter of a goose quill, continued from the upper part of the root, (an inch or two in length, and commonly twice as big as the stem,) bent into a form somewhat circular, and injudiciously formed into loose bundles, occupying unnecessarily much space, and consequently incurring a great and needless expense for freight. Both the root and stem, when broken, appear internally of a reddish colour, like that of madder. Wishing to obtain some more accurate information concerning this plant, than I had been able to procure, I questioned Dr. Roxburgh on the subject, previous to his last embarkation for India, and was assured by him, that it was unquestionably a species of rubia, or madder; and that it, in his opinion, might very properly be distinguished, by

giving it as a trivial or specific name the Hindu appellation of manjit'h; which I have accordingly done; as I find Dr. Fleming, on the same authority, has also done in his valuable account of East Indian drugs, (printed in the 11th volume of the Asiatic Transactions, 4to.) where he observes, that this species of madder is indigenous in *Nepal*, and is used by dyers and calico printers, in the same manner as the rubia tinctorum is in Europe. Dr. Roxburgh represented this to me as a creeping or climbing plant, and the stem as spreading or rising to a great extent; and he added, that unlike the stem of the rubia tinctorum, this of the manjit'h seemed to be preferred to the roots for dyeing; a circumstance which might be expected to render it *a very cheap dyeing drug*.

From the results of a great number of experiments, I conclude the colouring matter of this species of madder, in its general properties, to resemble very nearly that of the rubia tinctorum, but with this disadvantage, that on cotton and linen, its red is not so durable as that of the latter, though in calico-printing it gives much less stain to the white grounds, and, therefore, requires much less branning, and exposure on the grass. On the other hand, I find its red colour to be more bright and lively upon wool or woollen cloth when dyed with it, than that of the Dutch madder, and nearly, perhaps quite, as permanent; especially when solutions of tin are employed as the mordant. With these and the rubia manjit'h, I have repeatedly given to broadcloth a scarlet, which, seen by itself, might be supposed to have been dyed from cochineal, though when contrasted and compared with cochineal scarlets, a difference obviously presented itself, not in the vivacity of these colours, but in a greater inclination to the yellow tint, in those dyed from the manjit'h. This latter defect may,

however, be easily removed, by employing a portion of cochineal with the manjit'h; and by this mixture good scarlets might be produced with a considerable diminution of expense. I have in the former volume, recommended such a mixture of cochineal with Dutch crop madder; but the manjit'h is, I think, greatly preferable for this purpose. In regard to the durability of colours, given by the latter to cloth, with the basis of tin, I have ascertained, by sufficient trials, that it is fully equal to that of the cochineal scarlet. But on cotton *this basis* produced no more stability of colour from the manjit'h than it does from cochineal, though I employed it with a variety of auxiliary matters, such as galls, glue, oil, &c. Some very pretty reds have, within a few years, been given to muslins from this vegetable with an aluminous basis, and some addition, which is, I believe, a secret.

With iron and other metallic bases, this vegetable produces colours differing but little from those given by the same means, with Dutch madder.

After this statement, it will not be thought extraordinary that I should strongly recommend an increased importation of this dyeing drug, especially for the dyeing of woollen cloths, to which it has not, I believe, been hitherto applied, except in my own experiments on a small scale, though it certainly is preferable to Dutch madder for this purpose; and by grinding, and close compression in casks, or other packages, capable of excluding moisture, the expense of freight might be lessened more than one half, without any danger of injuring the quality of the manjit'h.

There is another species of madder commonly used in China and Japan for dyeing, viz. the rubia cordifolia, described by Thunberg, (Jap. 60.,) but I have had no opportunity of making any experiment with it.

CHAPTER IV.

Of Vegetables affording Red Colouring Matters, nearly similar to that of Madder.

"Most of those useful arts, and admirable inventions, which are the very support of mankind, and supply them with all the necessaries and conveniences of life, have at first been the production of some lucky chance, or from slight and contemptible beginnings, have been, by long experience, curious observations, and various improvements, matured, and brought to perfection."

Bishop Potter's Archæologia Græca, vol. ii. 120, 3d edition.

ARTICLE I.

Oldenlandia umbellata. Umbelled Oldenlandia of Roxburgh. The Ché or Chay, Chayaver, or Saya-ver, and Imburel of the Tamuls; and Tsheri-vello of the Telingas.

This plant, like madder, belongs to the natural order of stellatæ, and its roots are universally, perhaps exclusively, employed along the coast of Coromandel, and that of Malabar, to afford the durable reds for which the cotton yarn, and chintzes of those parts of India, have long been greatly esteemed.

Dr. Roxburgh, in his accurate and splendid work on the plants of Coromandel, describes this as being a small biennial, rarely triennial plant, growing spontaneously in very light dry sandy ground near the sea;* and as being moreover extensively cultivated, especially on the coast of Coromandel.—The cultivated roots are very slender, and from one to two feet in length, with a few

* Dr. James Anderson, late Physician-general to the East India Company, at Madras, in certain printed letters to Sir Joseph Banks, asserts that these roots "will only yield colour when cultivated on the *sea* coast:" whether they derive any thing useful from the vicinity of the ocean, excepting a loose sandy soil, I know not. The roots produced in stiff clayey ground, are said to be of little or no value.

lateral fibres; but the wild are shorter, and supposed to yield one-fourth part more of colouring matter, and of a better quality; and this resides almost entirely in the *bark* of the roots, which, when they have been recently gathered, is of an orange colour, and tinges the spittle yellow, though by being long kept, the roots become apparently colourless, or at most only retain a very pale straw colour. The roots gathered at the end of their *second* year's growth are considered as the best; but the farmer does not find it profitable to let them continue in the ground after the *first*.

I have mentioned at p. 263 of my first volume, the employment of these roots by the natives of Coromandel, &c., for calico-printing, or rather *chintz painting;* but they require to be more particularly noticed, in regard to the use which is there made of them in dyeing that beautiful and lasting red colour upon cotton, which seems to have preceded and can only be equalled by the Turkey red; and by comparing the means and operations employed to produce these colours, it will be found, that those which afford the Turkey red, must have been *suggested*, at least, by a knowledge of those antecedently employed with the ché or chay root.

It is remarkable, that though, (as was formerly mentioned,) an aluminous basis is prescribed and employed for the colour of this root, by all the instructions respecting its use in *calico printing*, and though a similar basis is particularly required for the reds dyed with it, upon calico, *when no oil is employed*, yet no mention is made of any such *basis*, in the accounts given by Father Cœurdoux and others, of the means employed by the dyers in Coromandel, and Malabar, to produce that colour which is analogous to the Turkey red. In these accounts they are said to form a mixture similar to the grey steep (or *bain bis*) lately described, excepting that

instead of soda, they employ a lye of wood, or other vegetable ashes, and instead of Gallipoli oil, that of gingelly or sesamum, which is rendered milky, by combining it with the alkaline lixivium; and to this they add either goat's or sheep's dung, which being dissolved, and equally dispersed through the mixture, they steep therein the cotton yarn, (previously cleansed by repeated macerations in water, and dryings in the sun,) during nine or ten successive nights; taking it out every morning, and spreading it widely to the sun's rays, during the day; after which the yarn is well rinced and dried. This being done, instead of *galling*, as in the Turkey red process, a cold infusion is prepared from the powdered leaves of the memecylon capitellatum,* commonly called *cassa*, or *cacha* leaves, (which have an *astringent* taste,) and in this the cotton is steeped once or twice, and dried after each steeping; by which it acquires a full deep yellow colour. After this it is macerated in another cold infusion of the bark of the roots of the nana, or nona tree, (which appears to be a species of guilandina,) and afterwards dried. But though in most places these infusions are applied separately, they are mixed in some, particularly at Masulipatam.

By these macerations, and subsequent dryings, and without the mention of any aluminous or other basis, the cotton is said to be prepared for the dyeing operations, to be described hereafter.

The Abbé Mazeas having made himself acquainted with the accounts of these operations, as given in the 26th and 27th "Recueil des lettres Edefiantes," and in certain manuscript relations, some of which were pro-

* Dr. Roxburgh describes this as being, in general, a shrub, though sometimes growing to the size of a large tree. It is the *Calamsaly* of the Malabars, and *allie* of the Gentoos.

cured by M. du Fay and others, furnished by M. de Rabec, (who had then lately returned to France from India,) and being persuaded, that in reality no aluminous basis was employed, to produce the red colour under consideration, (because no mention was made thereof in either of these accounts or relations,) he assiduously occupied himself with this subject, and endeavoured not only to produce a similar colour without the aluminous basis, but to discover and explain the principle or philosophy of an effect so extraordinary. He was perfectly aware that an aluminous basis had been constantly employed both in Turkey and France for the Turkey red, and that all the dyers of that colour firmly believed, that it could not be produced without that basis; but he considered this as an erroneous opinion, and endeavoured to account for its existence, by supposing, that the Turks, after being informed of the East Indian process, must have failed in their attempts to carry it into practice, and that after this failure, they had with more success resorted to the means employed by Europeans for dyeing thread and yarn; I mean those of aluming and galling; which had thus been unnecessarily superadded to those employed on the coast of Malabar and Coromandel. It appears from his memoir, intitled "Recherches sur la cause Physique, de l'adherence de la couleur Rouge aux toiles peintes, qui nous viennent des cotes de Malabar et de Coromandel," and from his Appendix to that Memoir, (printed among the "Memoires de Mathematique et de Physique," presented to the Royal Academy of Sciences at Paris, "par divers Savans," tom. iv.) that all his endeavours to produce the desired colour without an aluminous basis, were unavailing, until he had *substituted hog's lard* for the vegetable oil commonly employed; but that with this substitution, he succeeded in dyeing *one small*

hank or skein of cotton yarn, ("un petit écheveau de coton,") with a red colour which supported boiling with soap, ("qui a resisté au de bouilli du savon;*) and considering this as a sufficient evidence of the practicability of producing the desired colour without any aluminous basis, he proceeds to reason upon, and explain, the supposed fact, without any discoverable attempt to establish or confirm it by a *second* experiment, though from its most extraordinary *and* incredible result, he ought to have considered several repetitions of his experiment, and with constant success, as being necessary to convince others, that he was neither deceived himself, nor been inclined to deceive. But the philosophers of that time (1774) appear to have been so indulgent, that no one publicly questioned this supposed fact, and the Abbé's explanations concerning it were received in different parts of Europe with great applause, and have been since deemed an adequate foundation for various theoretical notions of the *practicability* and *utility* of imparting to linen and cotton, a certain *animalization*, to enable them to imbibe and retain colouring matters, more copiously and permanently than they could otherwise do.†

* He does not say how long it did this. It might have been for even less time than the common madder red will bear this trial.

† The following are the Abbé's principal reasonings and conclusions from his experiment, viz. "Il suit de la, que les huiles animales sont plus propres a l'operation, que celles que nous tirons des végétaux en Europe; mais par quel *mechanisme** ces huiles retiennent-elles les parties imperceptibles, qui, dans les excrémens animaux, se joignent aux atomes colorans de la garance? Il est d'autant plus difficile de l'expliquer, qu'on ne remarque aucune difference sur les fibres, qui ont été empreintes du

* Every thing at that time was to be explained upon mechanical principles.

It will have been seen, by the opinions which I have delivered on this subject in the preceding chapter, that I am not disposed to deny the efficacy of some animal matters toward enabling linen and cotton to acquire more durable colours in dyeing, than any which we as yet know how to communicate, without them; but this, so far as my experience reaches, is done by some peculiar property, besides that of their animal nature, and only in conjunction with some earthy or metallic basis. Indeed, numerous experiments have convinced me, that if it were practicable, by the application of such matters completely to change the *nature* of linen and cotton, and give them not only the *chemical properties or affinities* of wool, but also the advantage of its porous and tubulous structure, it would still be impossible to make it capable of acquiring, either from madder or the chay

savon, tel que je viens de le decrire, soit que l'on supprime ou non, les excrémens animaux. Cependant cette suppression fait une grande différence pour la couleur, car le coton ne la prend pas, toutes les fois que l'on emploie le sain-doux, sans employer les crottes de brebis; preuve évidente que les graisses des animaux, ne contiennent point les molécules, avec lesquelles la garance a tant d'affinité.

"S'il m'étoit permis de me livrer à des conjectures, je croirois que toute l'opération se réduit, à dépouiller le sain-doux qui s'est joint aux molécules excrémentielles, de toute sa partie grasse, et qu'il ne reste plus sur les fibres du coton, que la partie terreuse de cette graisse, indissoluble aux alkalis savonneux: mais il est bien difficile de s'en assurer par l'expérience; ici la nature disparoit a nos yeux, ou plutôt elle se voile sous un *mechanisme* si délicat, qu'a peine laisse-telle quelque prise a l'imagination.

"Je me borne donc au fait que je viens d'etablir."

"L'essentielle, avant d'aller plus loin, etoit de *constater le principe*, et de faire vóir *que dans cette espèce de téinture, les atomes colorans se jettent immédiatement sur la substance animale*, et non sur la *terre blanche d'alun*, comme il arive dans la teinture d'Andrinople." See p. 21 and 22 of the volume recently quoted.

root, a colour like that in question, without the aid of some basis or means beyond those stated to have been employed by the Abbé Mazeas in his successful experiment: I have, indeed, repeated that experiment, and made others upon similar principles without success, and I have, therefore, but little difficulty in believing, that in regard to the results of that experiment, he must have been deceived; probably by supposing, unwarrantably, that his colour possessed a much greater degree of stability, than it could have done without other means.

But what are we to think of those who, more recently as well as formerly, have, in their communications, omitted to mention the employment of any preparation of alum in dyeing the Malabar and Coromandel red upon cotton yarn, from the chay root? Did this omission proceed from ignorance* and inattention in the authors of these communications, or from studied concealment in the Indian dyer; or is it more probable that the water employed by them may naturally hold alum in solution, and that this fact may have been overlooked, by persons who were not properly sensible of its importance?† That the colouring matter of the chay root does not possess any peculiar property, which could enable it, without alumine, to produce effects which the dyers of Turkey red have found it impossible to obtain from

* When persons do not understand the principle, or cause upon which the success of an operation depends, it must always be difficult for them to describe it completely, or without overlooking something of importance.

† Dr. Taylor, Secretary to the Society of Arts, Manufactures, and Commerce, who possesses great theoretical and *practical* knowledge on the subject of dyeing, and was formerly engaged extensively in the dyeing of Turkey red, told me very lately, that the *last* of these suppositions appeared to him to be the most probable.

madder without that basis, I am well convinced by a multitude of trials; I have, indeed, found that when cotton had been fully impregnated with oil, the soluble parts of sheep's dung and of gall nuts, its attraction for the colouring matters both of madder and of chay roots, was considerably increased, but not in any degree which could at all warrant a belief of its being practicable, by such means *only*, to produce any colour similar to the Turkey red, and yet, in addition to the omissions in the several accounts already noticed, I have to observe, that there is *no mention of alum* in the communication lately made to the Society of Arts, Manufactures, &c. by Mr. Machlachlan, of the process for "dyeing the beautiful reds of the Coromandel Coast, from chaya root, and the leaves of cashaw, or cashan," (see the 22d volume of their Transactions;) nor in that which was recently made by Mr. Benjamin Heyne, acting Company's Botanist on the Coast of Coromandel, (in a letter,) to the Right Hon. Lord Hobart, (now Earl of Buckinghamshire,) of the method used by the Malabars, of dyeing a beautiful and lasting red on cotton yarn, with the chay root, &c. of which I was favoured with a copy by Dr. Roxburgh.

This communication by Mr. Heyne, would probably have obtained a greater portion of my confidence, if he had appeared either to have known *more*, or not to have known so much, on the subject; and especially if he had not been so manifestly influenced by the reasonings of Mr. Gren in regard to the supposed *animalization* of the cotton dyed by this method; to which animalization he *exclusively* imputes the stability of this colour, and seems to believe (erroneously) that the first notions of its utility originated with Mr. Gren.

It appears, by Mr. Heyne's account of the Malabar practice, that the cotton yarn is divided into small

skeins of only thirty or forty threads each, and so attached to bamboo sticks, that, when spread, every single thread may be exposed to the powerful rays of the sun; after which, being put into cold water, it is beat and pressed by hands, during half an hour, and then left to steep until it begins to emit a *putrid smell*, which it will commonly do in that climate at the end of thirty-six hours; when this happens, the yarn is well washed, then beaten upon a stone, and afterwards exposed to the sun. Mr. Heyne supposes, that the former part of this operation may separate some mucilaginous, gummy, or other vegetable matter, which might obstruct the action or combination of the other matters which are to be subsequently applied, and that by the subsequent *beating*, the texture or twistings of the threads must be so loosened as to render each fibre more accessible to these matters.

The next application, and the only one containing animal matter, resembles the grey steep, or *bain bis*, already described; excepting the substitution of a lixivium from the ashes of burnt vegetables, for that of soda, and of the *gingelly* oil* for that of Gallipoli, and, excepting an addition which is made to it, of a liquor called zickey, to be soon described. Mr. Heyne computes that for each pound of yarn, it may be necessary to employ in this steep one pint of oil, two quarts of lye, and half a pint of zickey, with five or six ounces of sheep's dung. When this mixture is made, the yarn is to be soaked and squeezed in it, for half an hour, then spread out, two or three hours, to dry in the sun; then soaked, and squeezed again, and afterwards spread

* Mr. Heyne says, the Malabar name of the *sesamum* orientale, which affords the gingelly oil, is elloo, and the Gentoo name, noovoo-chittoo; and that the dyers never use it until, by keeping it a year or longer, it becomes *rancid*, and of a *yellow* colour.

out to dry, in the same manner, and finally soaked, squeezed, and dried a third time, all in the same day; after which, the cotton is to be put back into the steep, and left to macerate during the night; and in the morning, the three soakings, squeezings, and dryings, of the preceding day, are to be repeated, and at night the cotton is to be again macerated, &c. which treatment is to be continued during ten days; it is, indeed, prolonged by some of the dyers, with a few slight alterations, for a longer term. When the cotton is supposed to have imbibed a sufficient portion of this, which Mr. Heyne considers as being an animalizing mixture, though it contains nothing of an animal nature but the dung of sheep feeding on vegetables, it is to be washed in clean water; and the matters separated from it by this washing, are to be preserved (with the water employed in the washing) for the space of a year, or until the liquor has acquired some degree of ropiness with a putrid smell, when it takes the name of zickey, and is employed, as before mentioned.

After this treatment, the cotton is to be thoroughly wetted, by repeated dippings and squeezings in water, rendered almost as thick as paste, by a previous admixture of the powdered cassa, or casha leaves,* lately mentioned, and afterwards left to soak in this mixture during the night, and being rinced the next morning, it is to be dried in the sun, and afterwards soaked during one night in an aqueous infusion, made with two handfuls of powdered chay roots, and two handfuls of the

* Mr. Heyne says, these dyers will never make use of the leaves growing near their own habitations, even though (as sometimes happens) they are obliged to pay unreasonably for those brought from distant situations; and he appears to think there is a considerable difference between the leaves produced on the sea coast and those of more elevated districts.

leaves of the same plant, for each pound of the yarn, and dried in the sun the following day; which soaking and drying is to be repeated the two following nights and days. But on the fourth night, the soaking is to take place in an infusion of the chay *roots* without the leaves. On the fifth day, some of the powdered cassa leaves are to be formed into a paste by rubbing them with gingelly oil, and this paste is to be mixed with a quantity of powdered chay root in water, and in this the yarn is to be soaked during the night, and dried in the sun the following day: and this soaking and drying is to be repeated three successive nights and days; after which the yarn is to be *dyed* by putting it into warm water, with a sufficient quantity of powdered chay root, and bringing it gradually to a boiling heat, which is to be continued until the yarn is supposed to have acquired sufficient colour. But if the dyer afterwards thinks it defective, the cotton is again to be soaked in a cold infusion of casa leaves and chay root, powdered, and again boiled with the latter.

This tedious process, of which I have given an account in as *few words* as possible, occupies almost a month, and is said to be also practised, with some unimportant variations, along the coast of Coromandel, from Cape Comorin to Palliacottah, but to be *unknown in the northern Circars, and in Bengal.* The colour, though not very *bright at first*, because its superfluous and brownish parts are not separated by a brightening process, (as they are in the Turkey red,) constantly improves by wearing and washing.

It will have been observed, that no blood is used in dyeing this colour, and that the cotton imbibes a great proportion of its red colouring matter by being repeatedly soaked in the *cold* infusions of powdered chay root. The subsequent *boiling* with more of that root,

while it supplies additional colouring matter, probably unites or combines that which had been previously applied more firmly, by giving greater force and energy to the *attractions* of the several matters which are intended to co-operate in producing and fixing the colour; and of these, I am convinced that alumine, applied in some way or other, *must be one*, though Mr. Heyne, (who appears to have seen most of the operations described by himself,) *distinctly asserts*, that any such addition would be not only useless, but injurious to the *beauty*, at least, of the colour; an assertion which I know not how to believe, considering that the Turkey red, dyed upon the *aluminous* basis, is at least equal to that of Malabar in *beauty* and permanency. This I know by a skein of very fine *Malabar red cotton yarn*, which I received from Dr. Roxburgh, and which I have compared and tried in various ways with samples of the best Turkey red, dyed in Great Britain and France.

I am, indeed, the more disposed to consider Mr. Heyne's communication as defective in regard to the use of alum, because I find the latter mentioned as equivalent to, and capable of being substituted for the cassa, or allie leaves, in a manuscript account given by Mr. Ram, "of the method of dyeing *red* with the *chay root* in the Guntoor Circar;" which manuscript was also put into my hands by Dr. Roxburgh. From this account it appears, that the cotton, after being treated nearly as Mr. Heyne has described, until it is supposed to have sufficiently imbibed the matters imparted by the grey steep, (composed of an alkaline lixivium, gingelly oil, sheep or goat's dung, and zickey,) is to be washed in clean tank water, and well dried; and then "half a pucca seer of the powder of allie (cassa) leaves, *or two dubs weight of alum*," are directed to be put, with a suitable quantity of water, to the cotton: but as the properties of

the *allie* leaves, are so very dissimilar to those of alum, that one cannot be supposed to produce the effects, or answer instead of the other, I think it most probable that Mr. Ram's account would have been more correct, and conformable to the practice of the dyers of the Guntoor Circar, if he had mentioned the alum as being employed, not *instead* of the allie leaves, but subsequently to them; which, considering their astringent property, would have been similar to the practice of the Turkey red dyers, who employ the alum steep immediately after that of galls.

A large quantity of chay root was brought to this country about ten years ago, on account of the East India Company. Until this importation, my only experiments with this root had been made upon a small parcel which grew in the garden of the late Mr. East, at Jamaica, and which, from some defect (as I supposed) in the soil or situation where it was produced, afforded me but very little colouring matter.

In consequence, however, of this importation by the India Company, I was abundantly supplied, and through different channels, with chay root for my experiments; but though some parcels of it were better than others, none of them produced effects equal to the expectations which I had formed in regard to the properties of this root; and I found, also, that of the several dyers and calico printers, to whom samples of it had been sent, no one had succeeded with, or was disposed to adopt the use of it. This want of success led me to suspect that the imported roots had either been defective in quality when shipped, or had afterwards suffered injury, by age, or, more probably, by the warmth and humidity of the places in which they were stowed to be brought to Europe; and this suspicion was afterwards confirmed, by comparing the results of my experiments and examina-

tions with the rules and marks for distinguishing the *good* from the *defective* roots, which had been mentioned by Mr. Heyne, in his letter to Lord Hobart.*

But having long been anxious to ascertain the properties of a dyeing drug so much celebrated as the chay root, I endeavoured to procure for my experiments some of that which had suffered the *least* of any in the parcels imported by the India Company, which I was the better able to do, because the greater part of that importation having fallen into the hands of one of my particular friends; and I afterwards bestowed no small portion of my time and attention in making what appeared to be the most proper trials therewith: and by these I satisfied myself that the red colour produced by the chay root, in combination with an aluminous basis, not only on wool, but on linen and cotton, resembled very nearly, in its appearance and permanency, that given by madder with the same basis. It did not seem in any instance to excel that of madder, and sometimes

* Mr. Heyne in this letter, after describing the chay root as being not less important for dyeing and calico printing in that part of India, than madder is in Europe, observes, that great care is necessary to ascertain that it is of good quality, and has not been injured by exposure to rain, or by being kept in *damp* situations: of such injury, says he, " a certain sign is, *that a white colour prevails on the inside of the bark, and in its woody part;* as, on the contrary, a *green colour* may be taken for the *surest sign of its being good.*" He adds, that the *Malabar* dyers, in order to ascertain whether the chay roots have been well preserved, mix some of their powder with a little quick lime in water, and if it affords a fine bright red, they deem it to be good; but the *contrary*, if the colour be only a brownish or dull red. That the natives keep the roots with their stems together in large bundles, secluded from rain and damp air; and avoid pounding the roots until they are wanted for immediate use. Then they are carefully separated from the stalks, their small fibres cut off, and the better parts of the roots farther dried, to facilitate their reduction to powder.

appeared less beautiful, and less durable; but this difference when it occurred, might, as I thought, be reasonably attributed to the injury which the chay root had probably suffered in its quality. When applied to calico *printed* with acetite of alumine, the effect was much like that of madder, excepting that the white grounds were less stained.

With the solutions of tin, the chay root produced a very *bright* and lasting red on wool; though, like that of madder, it inclined a little too much to the orange; galls employed with the chay root in dyeing wool, made the colour incline still more to the yellow, as well on the tin as the aluminous basis.

The most remarkable difference in the colouring matters of these roots, was that which regarded their effects with the solutions or oxides of iron, which, with chay root, produced nothing *darker* than *drab* colours, either upon wool or cotton.

Woollen cloth boiled with a solution of lapis calaminaris (oxide of zinc) with muriatic acid, and dyed with powdered chay root, took a bright apple green; and, by substituting a diluted nitrate of lead, as the mordant, a bright cinnamon colour was obtained from this root.

By the Turkey red process, the colouring matter of the chay root produced effects so much like those of madder, that I was confirmed in my belief that the means of fixing its colour, as in the Malabar red, must be *substantially* the same as those employed with madder in Europe, for the Turkey red. Broadcloth, dyed without any basis, obtained from chay root a brownish red, which was, certainly, neither so bright nor durable as that which it imbibes in the same way from madder; for, by a fortnight's exposure to the sun and air, even in winter, it was reduced to a buff colour; a strong indication of the necessity of an aluminous or other basis,

to *raise* and *fix* the colour of chay root, even on a substance by its nature completely *animal.*

In regard to future importations of the chay root to this country, I think they can *never* be adviseable. A large quantity of it was sent to France, about the year 1774, on account of the then French East India Company; of which no beneficial use could be made, by any of those who attempted to employ it, probably, because it had been damaged, like that since imported to this country. It is true, that M. Le Goux de Flaix endeavours to account for this want of success, by supposing, *most erroneously*, that the purpose for which this root is employed in the East Indies, and the only one which it can answer, as he imagines, is *not that of giving colour*, but of *fixing* the colour of *other matters* there employed with it, in dyeing and calico printing. (See Annales des Arts et Manufactures, No. 51.) This error, however, as it rests on no evidence, and is contradicted by the best of testimony, as well as by many known facts, does not deserve any farther notice: and I conclude from the defective quality of these several importations, that this root must be liable to injury from some cause, naturally, and perhaps, unavoidably connected with a voyage from India to Europe. But if it were possible to obviate all injury of this sort, I should still believe, that no profit or benefit could result from any future importation of chay root to Great Britain. It can produce no effect which may not be as well obtained from madder, and, as I think, more cheaply. The roots, though very small, consist of so great a portion of *tough woody fibres*, yielding little or no colour, that as far as I can judge, two pounds thereof will not produce more effect than one of madder; probably not so much; and as it is most liable to be injured by moisture when reduced to powder, the unground roots can alone be imported, and those must

occupy so much space, as greatly to augment the expense of freight; and being, moreover, extremely *hard and tough*, the cost of grinding a given weight of them will, at least, be double that of grinding an equal weight of madder roots, and consequently, must augment, in a four-fold degree, that part of the expense of employing this Indian production in Europe.

ARTICLE II.

Galium.

This genus of plants belongs, like the preceding, to the natural order of Stellatæ, and consists of forty-eight well-ascertained species, whose roots, with perhaps a few exceptions, contain a red colouring matter, very similar in its properties and effects to that of madder; though, when the brown external covering of the root has been completely separated, the colour which it gives to wool is certainly *brighter* than that of madder, at least upon the aluminous basis.

The several species of the galium most esteemed and employed in dyeing, are, 1st. Galium tinctorium. This abounds in the woods of North America, and is called by the French inhabitants of Canada, *tyssa voyane* rouge, and employed by them to dye their cloths red, as it was by the aboriginal Americans, to dye their porcupine-quills, &c. of that colour. I have made some experiments with two small parcels of this root, one of which was brought from Hudson's Bay, and the other from the country of the *Cherokee* Indians, (westward of Carolina,) both of which communicated a very bright and lasting red colour to woollen cloth and to calico, with an aluminous basis, and with iron, colours resembling those of madder, upon the latter basis. Broadcloth, prepared with the nitro-muriate of tin and cream

of tartar, as for scarlet, and dyed with these roots, obtained a more lively red colour than that given by them with alum.

The roots of this species of galium are of a dark reddish colour, and though nearly two feet in length, are very slender. These, if I do not mistake, are the roots mentioned by du Pratz, (in his history of Louisiana,) under the name of *achechy*, as being full of red juice like chicken's blood, with which, says he, the tribes about the Mississippi give a beautiful red to their feathers, &c.

The Transactions of the Agricultural Society of New York, contain, as I am informed, an experimental Essay on the properties of galium tinctorium, its uses, &c. by Professor Woodhouse, which essay I have not been able to procure.

2d. Galium verum; yellow ladies' bedstraw, or cheese renning. Dr. Cuthbert Gordon, about twenty-five years ago, warmly solicited the attention of the Committee of Privy Council for Matters of Trade, &c. to the cultivation and use of this species of galium, not merely as a substitute for madder, but in some degree of cochineal also; alleging that a scarlet colour might be produced from it, which in beauty would almost equal that of cochineal, and surpass it in durability: and, indeed, some specimens of the colour which I have now before me, and which were said by him to have been dyed from this root, are but little inferior to a great part of the scarlets commonly dyed with cochineal. Dr. Gordon, for his exertions on this subject, obtained a small remuneration, (200*l.*) and some attempts were made by the Committee of the Privy Council to promote the cultivation of this plant; but, I believe, they were not attended with success, and probably the quantity of colouring matter which the roots afford, is not sufficient

to compensate the expense of bringing them to a state of maturity, which requires at least four years. They are covered by a very dark skin or bark, which must be separated, that its brown colour may not injure that of the other part of the root. Like madder and chay root they rapidly absorb moisture, unless secluded from it, and suffer great injury by doing so. The flowering stems of this plant afford a yellow dye, though it is not much esteemed. According to Pennant, Lightfoot, and others, the roots of this species of galium are commonly employed by the people of the highlands, and of some of the islands of Scotland, particularly Jura and Ulot, for dyeing a bright red upon their woollen stuffs. Its colouring matter is placed almost exclusively in the inner bark of the roots, and it seems necessary to employ, at least, three times as much of them as of madder, to produce equal effect. If propagated for dyeing, it should be planted in a very deep loose sandy soil, having some intermixture of marl.

3d. Galium mollugo; or great ladies' bedstraw, commonly called wild madder, and great bastard madder. Its roots are a little larger than those of the former species, and they produce, by dyeing, a red colour equally bright and lasting.

4th. Galium sylvaticum; wood ladies' bedstraw: the rubia sylvatica levis of Bauhine. Its roots dye red, like the preceding.

5th. Galium boreale; cross-leaved ladies' bedstraw: rubia pratensis lævis acuto folio of Bauhine, Pinax 333.

I have made no trials of this root, which is said to afford a more lively and beautiful red than the roots of any other species of galium. Haller says, that in Switzerland the roots are ground with the dust of malt, and afterwards infused in small beer, and that woollen yarn, being first macerated and afterwards boiled in this mix-

ture, acquires a fine red colour: probably alum is employed at the same time, though he does not mention it.

6th. Galium aparine; common rough ladies' bedstraw; cleavers, or goose grass. The roots of this species also dye red, but the colour is less pure and vivid than that of galium boreale; which is, also, the case of several other species of this genus, particularly galium purpureum, or purple ladies' bedstraw, and galium cruciatum, or cross wort.

Most, and probably all, of the species of galium, before mentioned, impart (like madder) a red colour to the bones of animals, with whose food the powdered roots have been mixed.

Very nearly related to galium, and possessing a similar colouring matter, are the roots of several species of the genus *asperula;* woodroof, or woodrowel, particularly asperula arvensis, blue or field woodroof, which Bauhine considered as a species of madder; and also,

Asperula tinctoria; or dyers' woodroof, the roots of which, according to Linnæus, are used for dyeing red instead of madder, particularly by the inhabitants of Gothland.

ARTICLE III.

Morinda Citrifolia, Linn. A Shrub, (sometimes arboreous); the Bancudus small Latifolia of Rhumphius; Coda-pilava of Rheede, and of Ray; called Aal, *in Malava, and* Atchy, *in Oude.*

This genus, like those of rubia, oldenlandia, and galium, is included among the *rubiaceæ* of Jussieu; but it does not, like the others, appertain to the natural order of stellatæ: and its colouring matter partakes so much of the orange, that it is only by being concentrated and accumulated in the stuffs dyed therewith, that it produces a red colour, always inclining a little to the orange

tint. Indeed, one species of this genus, the morinda umbellata, is employed in Cochinchina, and other parts of Asia, as a yellow dye; and the genus itself is so nearly related to that of morus, which contains the dyer's mulberry, (improperly called old fustic,) that its name was thereby suggested to Vaillant, and composed from the words *morus indica.*

The colouring matter of the morinda citrifolia, resides chiefly in the bark of the roots of this shrub; and as the smaller branches, or divisions of the root, contain the least proportion of woody fibres, and, consequently, yield most colouring matter, they bear the highest price.

When Mr. Alderman Prinsep returned to this country from India, more than twenty years ago, he favoured me with a box filled with small roots, broken into a coarse powder, and in colour differing not much from madder: to this he gave the name of *aurtch*, adding, that it was "the Bengal substitute for madder; and that, if better pounded, it would answer in the proportion of *three to two* of the latter." He gave me no information concerning the ways and means of employing this substitute in Bengal; but I find in the Asiatic Researches, (vol. iv. p. 35. 4to.) a communication by Wm. Hunter, Esq. respecting this species of morinda, and the red colour dyed with it, in that part of India, from which, and several coroborating circumstances, I am convinced that the roots given to me by Mr. Prinsep are no other than those of morinda citrifolia.*

I lately mentioned that the Malabar and Coromandel red dye from the chay root, was not known to the Bengal dyers; and, so far as I can discover, they supply its

* Probably the name of *aurtch*, employed by Mr. Prinsep, has been derived from that of atchy, which the morinda citrifolia bears in the province of *Oude*.

place by that which is produced from the roots of this species of morinda.

By Mr. Hunter's account it appears, that the cotton to be dyed by these roots, is first macerated in a lixivium of soda mixed with the oil of sesamum, then rinced and dried. It is afterwards soaked in an aqueous infusion of the large *her*, or *har*, (which is the ripe astringent fruit of the terminalia chebula, a species of myrobalan,) and, after the infusion has been moderately squeezed from it, the cotton is exposed to the rays of the sun during four or five days, in which it will acquire a cream colour. It is then macerated in a solution of alum, (made by employing one pound of water, to each ounce of alum in powder,) and after being thoroughly and equally penetrated by this solution, the superfluous part of the latter is to be separated by moderate pressure, and the cotton again exposed four or five days to the sun, that it may be well dried; and this being done, it is rinced in cold water, and again dried. Three gallons and one half of water are then put into a copper dyeing pan, placed over a fire, and the cotton immersed therein, so that it may be equally and thoroughly wetted; this being done, add from one to two seers of *aal* (i. e. the roots of morinda citrifolia,) in powder, (according to the quality of the powder,) having first rubbed and well mixed the latter with the oil of sesamum, at the rate of two ounces for each seer of the powdered roots. Put also into the pan, one eighth of a seer of the flowers of *d'hawry** for each seer of the *aal;* or, instead of these flowers, one ounce and one half of purwas, (a sort of gall nut,) in powder. The cotton and other ingredients, just mentioned, are to be kept over a very moderate fire during three hours, at the end of which, the liquor is

* This vegetable is the lythrum fruticosum of Roxburgh.

made to boil until the colour is sufficiently raised; the cotton being constantly stirred, and frequently lifted above the dyeing *liquor*. If the latter becomes red, it is supposed that the colour of the cotton will be defective, unless a farther portion of the flowers of d'hawry be added. The red colour dyed in this way, is said by Mr. Hunter to be more esteemed for its *great durability* than for its beauty. He adds, that with a basis or solution of iron, these roots dye lasting purple and chocolate colours; that they penetrate three or four feet into the earth; that great quantities of them are sent to Guzerat and the northern parts of Hindostan.

Presuming that the roots which I received from Mr. Prinsep, as being the Bengal substitute for madder, must be those of the morinda citrifolia, I shall here mention the results of my experiments with them, in dyeing *woollen* and *cotton* stuffs.

To the former, prepared as usual by being boiled with alum and tartar, these roots communicated by dyeing in a moderate heat, as with madder, a bright red colour, inclining a little to the orange tint, which, by subsequent exposure to the sun, rain, winds, &c. proved to be very durable.

Broadcloth prepared by being boiled with nitromuriate of tin and tartar, as for the cochineal scarlet, acquired a very bright colour, but little inferior in vivacity to the colour which would have been produced, if the cloth so prepared had been dyed with cochineal, but partaking too much of the orange to be deemed a scarlet. Indeed, it very much resembled the colour which I lately described as having been produced by the rubia manjit'h upon cloth prepared in the same way; and this colour was also found to be very durable.

Calico, printed with the acetates of alumine and of iron, both separately and mixed, being afterwards

cleansed as usual, and dyed with the Bengal substitute, took red, purple, and darker colours, very much like those which would have been produced by madder with the same bases or mordants, and equally durable. With other bases, colours were produced not differing much from those which madder would have produced with the same means. And I am, therefore, induced to believe, that importations of this root, to be employed here instead of madder, might afford profit to the importers, and benefit to the public. There is certainly no danger of its suffering like the chay root, either by a sea voyage, or by long keeping in this country, at least if proper care be taken of it; the parcel given to me by Mr. Prinsep having now been more than twenty years in my possession, without any perceptible deterioration, though powdered, and never secluded from atmospheric air, even when the latter was unusually damp. Care should, however, be taken previously to bring these roots into a state, in which they will occupy the least possible space, and be liable to the least expense for freight, &c.

I may be here allowed, as I hope, *slightly* to notice a few other red colouring matters, which, though they do not strictly appertain to this chapter, cannot be referred to any other, without greater impropriety.

Of these, the first is the anchusa tinctoria, or dyers' alkanet; the root of which abounds in a dark red colouring matter, readily soluble in acohol and in oils. It was employed to dye wool by the ancients, as is mentioned by Pliny, lib. xxii. c. 20. and has been used for the same purpose by the moderns, particularly in France, though the use of it in this way seems to be now generally discarded, that of madder being found much more advantageous. Haussman, indeed, states, in the Ann. de Chimie, tom. 60, that if the colour of this root be ex-

tracted by alcohol, and applied by dyeing to silk or cotton which have previously imbibed the aluminous basis, it will communicate a beautiful and sufficiently permanent purple violet colour, (pourpre-violet,) but this menstruum would be too costly in this country. The roots of the anchusa virginica, called puccoon in that part of America, possess a colouring matter nearly similar, and were formerly employed by the savages to paint their naked bodies.

The roots of the sanguinaria canadensis, or Canadian blood root, so called by Morinus, and after him by Dillenius, from the blood-red colour which the juice of the fresh-gathered root exhibits, (but which changes to an orange by drying,) are sometimes employed by the inhabitants of South Carolina for giving an orange colour to silk and muslins, though it soon fades, and was found, by many experiments which I made with it, incapable of being rendered permanent. This seems, also, to have been called puccoon by the savages there, and was, as is mentioned by Catesby, employed with bear's oil to paint their skins. With a solution of tin it produced a bright orange on silk. It possesses a violent emetic quality.

I received, some years ago, from Dr. Roxburgh, a small parcel of the red powder, which covers the capsules of the rottleria tinctoria, or wassunta-gunda of the Telingas, which powder is a noted dyeing drug, especially among the Moors in the East Indies, and forms a considerable branch of commerce from the mountainous parts of the Circars. The colour of this powder seems to be intermixed with a portion of resinous matter, which renders it but little soluble in water only, but being made soluble by an admixture of soda, I found it afterwards capable of dyeing a very high and bright orange, with alum and with the solutions of tin, which orange colour was sufficiently durable on silk, but less so on cotton.

Barrere, in his Nouvelle relation de la France Equinoctiale, p. 39, mentions a species of convolvulus, growing about the river of Amazons, and called by the Carribbees, kariarou, which yields a pulp as red as vermilion, (" une fæcule aussi rouge que le vermillon d'Espagne,") and which the savages and Portuguese employ to dye their cotton hammocks. He calls it " convolvulus tinctorius folio vitigineo;" I endeavoured, when in Guiana, to procure some of this colouring matter, but without success.

The Danais of Commerson, is a creeping shrub, appertaining to the *rubiaceæ* of Jussieu, which, as we are informed by M. du Petit Thouars, the people of Madagascar employ as a red dye for the cloth which they weave from the thread of the tafia palm; but it has never been in my power to make any experiment with it.

CHAPTER V.

Of Brasil, and other Woods, affording red colouring matters.

"Peragitur progressio coloris rubei a Brasilio ligno, quod et Verzinum dicitur, utrunque enim ipsius ligni nomen deducitur a Provincia Indiæ utriusque nominis, &c.' CANEPARIUS DE ATRAMENTIS, p. 199.

ARTICLE I.

Brasil Wood.

THIS, and most of the woods to which this chapter is appropriated, belong to the genus *cæsalpinia,* so named in honour of Cæsalpinus, the father of the systematic arrangement of plants. It is the heart, or central part, of a large Brasilian tree, the cæsalpinia echinata. Other dyeing woods had, however, been previously known under the name of *Brasil;* and, probably, that of the cæsalpinia sappan, to be noticed presently.

It will have been seen by my quotation from *Caneparius,* at the commencement of this chapter, that he supposed, according to an opinion which has long prevailed, and which Berthollet has adopted, (tom. ii. p. 228,) that the wood under consideration, obtained its name of Brasil, *from* the country where it is indigenous, instead of communicating, *as it certainly did,* this name to that part of South America, which is now distinguished by it.

I have mentioned at p. 297, of my first volume, on the authority of Muratori and Bischoff, "an old charter, or contract, passed in the year 1194, between the cities of Bologna and Ferrara, by which a duty was to be levied in the former of these cities upon the *grana de Brasile*, meaning kermes;" and have stated, on the

same authority, that these Brasilian grains, "and also *Brasil wood*, were mentioned in other old charters, particularly one dated in 1198, and another in 1306, under the name of *braxilis*," which, as well as that of *brasilis*, is understood to have been "derived from *bragio*, a *burning coal*, (in French *braise*,*) which was suited to give the best idea of a very bright red, or *flame* colour; and as the sappan wood, which (like indigo, the spices, &c.) might have been obtained from India, through Egypt, Syria, &c., would, whilst the tin basis was unknown, have afforded that colour, with even more brightness than the kermes, it might also, with at least equal propriety, obtain the name of brasilis or braxilis. Certainly the dyeing wood so designated, could not have been an American production, as that quarter of the globe had not then been discovered.

That *red dyeing woods* were commonly called *Brasil* woods, long before this name had been given to the Portuguese territory in South America, may be proved, most unquestionably, by the most accurate and best informed narrator of the events of his own time, Peter Martyr, Secretary to the first (Spanish) Council of the Indies; who, in the fourth chapter of his *first* Decade, addressed to the Cardinal of Arragon, after giving an account of the second voyage of Columbus, (with whom he was intimately acquainted,) to America, (whence the latter had returned to Spain in March, 1495,) states, that not far from the mountains of "*Cibana*," in Hispaniola, "are many great woods, in which are none other trees than Brasil, which the Italians call verzino."

* In the original edition of the French Encyclopedia, I find "*brasiller*," mentioned as a verb neuter, and as a "terme de marine," used to signify "les *feux, et la lumiere* que jette la mer pendant la nuit."

And in the next chapter, when giving an account of transactions which occurred at Hispaniola, in the absence of Columbus, (i. e. previous to his third voyage,) Martyr mentions an excursion which Bartholomew Columbus, the Admiral's brother, made to the mountains of Cibana, where, having divided his men "into twenty-five decurions with their captains, he sent two decurions to the regions of those kings, in whose lands were the great woods of *Brasile* trees. Inclining towards the left hand they saw the woods, entered into them, and felled the high and precious trees which were to that day untouched. Each of the decurions filled certain island houses with the trunks of *Brasile*, there to be reserved until the ships came, which should carry them away." I have here given the words of the earliest English translation of Martyr's Decades, by Robert Eden, in *black* letter, not having at this time the Latin original, (which is indeed scarce,) in my possession. The second chapter of the first Decade, was finished on the day previous to the calends of May, 1494; but the third and fourth chapters appear not to have been written until the year 1500, about, or a little before, the time when Peter Alvarez Cabral sailed from Portugal with a fleet bound to the East Indies, by the Cape of Good Hope, and unexpectedly discovered the coast of that part of South America, which *nearly one hundred years afterwards* obtained the name of *Brasil;* but to which he then gave that of "*Santa Cruz*," after he had erected a *cross* upon a tree, at a place now called Porto Seguro. It is, therefore, impossible that Peter Martyr could have been led to give the appellation of Brasil to the trees in question, or their wood, from any connection, real or supposed, between them and a part of America, with whose discovery or existence he could not have been acquainted, when he made use of that

appellation. Indeed, the country since named Brasil, is not the only place which received that name from the *dye wood* under consideration; for the harbour now called Yaquimo, in Hispaniola, had been previously called *Brasil*, from the abundance of trees producing that, or a similar, dyeing wood, which grew on the neighbouring mountains; and, accordingly, Ferdinand Columbus, in his history of his father's life, informs us, that as soon as it was known in Spain that the latter, in his third voyage, had discovered Paria, and the country about the Orinoco, he was followed thither by Alonzo de Ojeda, (with whom Americus Vespusius had embarked,) and that, sailing thence to Hispaniola, on the 6th of September, Ojeda put into the port, which the Christians called *Brazil*, and the Indians Yaquimo, designing to take (forcibly) what he could from the Indians, and load with wood and slaves. The wood here meant was the *red* dyeing wood, after which the harbour had been *named*, and the slaves were the peaceable natives, who were intended to be kidnapped or stolen, and sold in Spain.

In the ninth book of his first Decade, P. Martyr gives an account of the voyage which Vincent Pizon and his nephew undertook from Palos, in December, 1499, and in which they sailed from the river Amazons westward, along the coast of Guiana and Paria; and when returning to Spain, in the month of October following, brought away with them great plenty of cassia fistula, &c. "They found, (says our author,) in some islands about Paria, great woods of Brasil trees, and brought away with them three thousand pounds weight thereof." "They say," adds he, "that the Brasil of Hispaniola is much better than this to dye cloth with a more fair and durable colour." Probably this, and some other red dyeing

woods,* which were soon after brought from different parts of the West Indies, under the name of Brasil, belonged to another species of this genus, the cæsalpinia crista, or to that improperly called cæsalpinia brasiliensis, both of which afford, what is now called braziletto wood.

For many years the wood, to which the name of Brasil is now strictly and exclusively appropriated, has been monopolized by the government of Portugal, and its exportation from the country which produces it, except for account of that government, has been prohibited under severe penalties. The best of this wood is shipped and sent from Fernambuca, formerly called *Olinda* Pernambuco, and is said to grow chiefly in the captainry, or district of Paraiba. It is called *pao do Brasil* by the Portuguese, and *ibirapitanga* by the Aborigines of that country. It is described as a large tree armed, or beset, both on the trunk and branches, with short *spines* or thorns; having leafets elliptic obtuse; racemes simple; and legumes prickly and bivalved, (each containing, according to Valentin, two red shining beans.) It is said to grow exclusively in elevated rocky situations, remote from the sea.†

There is, probably, a variety of this species, which

* In the fourth chapter of his seventh Decade, P. Martyr mentions, as having been recently brought from the West Indies, "*coccinean* wood, used for dyeing wool, which the Italian calleth *verzin*, and the Spaniard *Brasil*."

† Piso confirms this, he says, "In locis mari vicinis non apparet, sed tantum in mediterraneis sylvis, *unde magno labore ad littoralia vehitur*." Brasil. p. 164. Valentin agrees with Piso in this, and adds that they grow widely dispersed among other trees. The medullary part, or heart, is alone used in dyeing, and this bears so small a proportion to the sap, that when the latter is removed, the former, in a tree as large in circumference as a man's body, will be no bigger than his leg. It is red, hard, ponderous, and sparkles in burning.

is less an object of the vigilance of government in Brasil, and, therefore, sometimes clandestinely exported; I have several times been requested to make trials of this supposed variety, which had been sold in London as the *true Brasil wood*, smuggled from the place of its growth; and having done so, have invariably found, that though the colour which it produced resembled that of the wood supplied by the government of Portugal, it was greatly deficient in the *quantity* of its colouring matter, which never exceeded one third of that afforded by the true Brasil wood. How the tree producing this inferior wood is distinguishable from the other, I know not; and, probably, those who are best able, will not be disposed to favour a diffusion of knowledge on the subject. Indeed, it is possible that the difference may depend, in a great degree, on the ages of the trees producing these several woods. Dr. Roxburgh having observed, in regard to the sappan wood, that it is best when taken from the *oldest* trees, and this being also true of logwood.

Water, if copiously employed, and at a boiling heat, may be made to dissolve and extract all the colouring matter of Brasil wood, and, therefore, the practice, which is common among those who grind it, of sprinkling the powder with stale urine (which they call mastering) must be intended to raise and brighten its colour, by the volatile alkali which is thus applied to the powder in question.

There is a general persuasion, founded, as far as I can judge, upon experience, that by making a decoction of Brasil wood, and keeping it two, three, or more months, according to the temperature of the atmosphere, to ferment and become ropy, before it is employed for dyeing, better and more lasting colours

may be obtained, than could be produced from a decoction recently made.

Brasil wood does not appear to contain the smallest portion of tanning matter, though the contrary has been asserted by authors of great respectability. I have repeatedly mixed solutions of glue, and of isinglass, with recent decoctions of the genuine wood, but could never detect any coagulation, or precipitation, of gelatine, as resulting from any such mixture.

It is well known, that the beautiful *rose* colour which this wood communicates to water, is made yellow by acids, and purple by the alkalies and alkaline earths; and I may add, that its colour (as Chevreul seems to have first observed) disappears, or is made latent, by being secluded and confined a few days with sulphuretted hydrogene gas, like that of indigo, but probably not by a similar change. I mean an absorption of oxygene, because, as Chevreul also observes, the colour is restored by adding potash, without any admission of oxygene, and because I did not find that a decoction of Brasil wood lost its colour by being mixed, and secluded several weeks in a *close* vessel, (completely filled,) with sugar, and an oxide of tin, which was but little oxygenated, and, therefore, would have been capable of rendering indigo colourless.

With solutions of alumine and of tin, employed as mordants, this wood communicates a very lively and beautiful red to wool, silks, linen, and cotton; but, unfortunately, its deficient permanency, especially on the latter, renders the use of this wood much more limited than it would otherwise be.

With solutions of iron the colour of Brasil wood may be darkened so as to produce violet and black colours, of greater permanency than the red, but less durable than similar colours, which are given by cheaper means.

Alum, if put into a decoction of Brasil wood, even after it has been made yellow by an acid, will restore its red colour, precipitating a part of it, at the same time, and the remainder will nearly all subside, if the acid be saturated by the addition of an alkali. It is in this way that an inferior sort of carmine has long been produced,* for painting in water colours, and improving female complexions. The oxide also produces a fine rose-coloured precipitate from a decoction of Brasil wood, even when it has previously been made yellow by an acid.

I have found, by repeated experiments, that galls, when employed with Brasil wood for dyeing upon the aluminous basis, have rendered the colour more lasting upon linen or cotton; and this fact seems to have been long known, for in the old book, mentioned at p. 184 of my first volume, it was directed that linen, intended to be dyed with Brasil wood, should be prepared with *galls* and alum. Arsenic employed with alum, has likewise appeared to me, to render the red colour of this wood more lasting; but I do not recommend this addition, because the use of it is liable to dangerous accidents.

Having boiled broadcloth with sulphate of lime and a decoction of Brasil wood, for the space of one hour, I found it thoroughly dyed of a full crimson, which did not suffer greatly by a month's exposure to the sun, air, &c.

To dye wool or woollen cloth with Brasil wood, upon the aluminous basis, the former is commonly prepared, as directed at pp. 285 and 286 of my first volume; tak-

* Caneparius says, p. 215, "Conficient *laccam* ex Brasilio, Verzinove dicto;" and that they made red ink "ex ligno Brasilio, sive Verzino."

ing care, however, that the proportion of tartar be, to that of alum, only as one to five or six. But as that part of the colouring matter, which attaches and fixes itself most readily to wool or woollen cloth, does not produce the brightest colour, it is the common practice, first to dye some coarser cloth or stuff in the Brasil wood liquor, in order to deprive it of this least estimable part, before the finer cloth undergoes this operation. The liquor so improved, will also give a lively crimson to silk, which has imbibed the aluminous basis by the usual treatment. Calico, which had been printed with the acetate of alumine, and afterwards cleansed with a mixture of cow-dung in water, as is usual for calico printing, being dyed in a decoction of Brasil wood, obtained a fine crimson colour on the parts which had imbibed the aluminous basis, and a pale reddish discoloration on that which was *baseless*. Wishing to ascertain whether either the fat or the drying oils would afford any protection to the crimson colour so produced, I applied fine olive oil to some of the spots or figures which had received this colour, and linseed oil to others, and exposed the calico so dyed to the sun and air during ten summer days; at the end of which, I found that the colour which had been covered by linseed oil, was greatly faded, and that which had been covered by olive oil, considerably more injured than the crimson in other parts, to which nothing had been employed; so that both kinds of oil, instead of retarding, had promoted the decay of this colour.

Broadcloth prepared in a bath of alum and tartar, with about half as much of the murio-sulphate of tin as would be required for a cochineal scarlet, and dyed with Brasil wood, acquired a very lively and beautiful colour of a passable durability. The nitro-muriate of tin, employed in the same way, produces nearly similar effects;

but, by employing a portion of galls with the Brasil wood and the nitro-muriate of tin, a durable *orange* colour was produced upon woollen cloth.

M. Dambourney asserts, (see Recueil de procedes, &c. sur les Teintures, p. 172,) that he had found, by his experiments, the bark of the white birch (betula alba) to produce very beneficial effects, in fixing the colour of Brasil wood, conjointly with a solution of tin, made by equal parts of nitric and muriatic acids. But for this purpose he employed sixteen pounds of the birch bark to one pound of Brasil wood, which, he says, dyed four pounds of wool, of the colour which formerly was called Venetian scarlet (ecarlate de Venise.) He seems to think this bark equally efficacious in fixing the colours of logwood. I have reason, however, to doubt whether its effects are so considerable as he imagines, and the very great quantity, which he states to be necessary for producing these effects, will probably discourage its use.

As the oxide of tin has so little affinity for linen and cotton, it will hardly be supposed likely to give any considerable stability to the Brasil wood colour on these substances. It is, however, sometimes employed for this purpose, assisted by a large proportion of galls, or of sumach, which last tends less to degrade the colour than galls, and with it, the Brasil wood gives to cotton yarn a sort of scarlet, which, notwithstanding its fugacity, is found to answer for some uses.

A nitro-muriate of bismuth appeared, by my experiments, to be more efficacious than that of tin, for giving stability to the Brasil wood colour, both on wool and cotton, but it made the colour incline more to a dark crimson or purplish tint, than it does with the tin basis.

The oxides of antimony and of zinc, applied to wool,

gave dark brownish reds with this wood, but they were fugitive and of little value, and of still less on cotton.

The nitrate of lead, employed as a mordant with Brasil wood, produced a good bright red upon wool, but it did not prove sufficiently lasting; solutions of copper employed in the same way, produced dark but fugitive browns.

Wool, prepared with a nitrate of lime, and dyed with Brasil wood, obtained a deep orange colour of passable durability; and a lighter orange of less brightness was produced upon wool, by the sulphate of lime; but on silk, the latter produced only a cinnamon colour, though the nitrate of lime produced a deep orange upon this substance. Cotton received no colour from Brasil wood with either of these mordants.

ARTICLE II.

Sappan, or Sampfan, Wood.

This is obtained from the cæsalpinia sappan of Linn. a middle-sized tree, more prickly than the former, with leafits oblong-oval, unequal at the sides, obtuse and glabrous; calyx glabrous; stamina longer than the corols, and upper petal less.—See Roxburgh's Plants of Coromandel, vol. i. t. 16. It is indigenous to Siam, Pegu, the coast of Coromandel, and many parts of the East Indies, and was described by Rumphius, (Amboyna, iv. p. 56.) under the name of lignum sappan, and by Rheede (Hort. Malabar, vi. p. 3.) under that of *tsiapangam:* Linscoten had previously called it sapon. In some parts of Europe the name of sapon, or *sappan*, has been corruptly changed to that of *japan.*

This wood seems to have been very generally employed for dyeing in the greater part of Asia, during many centuries, and to have found its way to Europe some time before the discovery of America; though

very little of it has been lately imported, except by the Dutch.

The colouring matter of this species of cæsalpinia, differs but little from that of Brasil wood in its properties and effects, or in regard to the mordants required to produce these effects; but there is a considerable difference in regard to the relative quantities of colouring matter which these woods afford; that of the best sappan amounting, by my experiments, to little more than half as much as may be obtained from an equal weight of the Brasil, and the colour not being quite so bright.

I am informed that some of the trees, affording the true sappan wood, are now growing at the Isle de France, having been transplanted thither from Siam.

As the bases, or mordants, proper for the sappan wood, and also the ways of using it, very nearly resemble those which are found to be most beneficial with the Brasil wood, they need not be particularly described.

More than twenty years ago, the late Mr. Nathaniel Smith, then Chairman of the Court of Directors of the East India Company, put into my hands parcels of a species of red wood, which had been recently discovered at the Andeman islands, and of another red wood from the coast of Coromandel, with a request, that I would ascertain their properties for dyeing, compared with those of the true sampfan, or sappan, wood, from *Siam*, of which he also gave me a small parcel. The results, however, of my experiments were not favourable to either of the two first of these woods, as their colouring matter was but partially soluble in water, and both, in quantity and quality, appeared to be greatly inferior to that of the wood from Siam. The red wood of the Andeman islands, however, being boiled in water, with a little soda to render its colour more soluble, ap-

peared, in one respect at least, to resemble the lignum nephriticum, as its decoction, viewed by reflected light, exhibited a full *bright blue colour*, whilst, by transmitted light, it was red.

ARTICLE III.

Nicaragua, or Peach Wood, called by the French Bois de Sainte Marthe.

This seems to belong to the genus cæsalpinia, though the species has not, as I believe, been sufficiently ascertained. Sir Hans Sloane, in his Natural History of Jamaica, has mentioned it as growing about *Nicoja*, on the coast of the South Sea, or Pacific Ocean, and being thence brought by the Lake of Nicaragua to the North Sea. It is almost as red and heavy as the true Brasil, but does not commonly afford more than a third part in quantity, of the colour of the latter; and even this is rather less durable and less beautiful than the true Brasil wood colour, though dyed with the same mordants. It seems to be the curaqua, seu Brasilium Hispanorum, of Hernandez, (p. 121,) and is called, (though I know not why,) stock-vish-hout, or stock-fish wood, by the Dutch.

The woods sold under the name of Nicaragua, or peach wood, differ greatly in their quality as well as price; one sort being so deficient in colouring matter, that six pounds of it will only dye as much wool or cloth as one pound of Brasil wood, whilst another variety of it, growing principally about the Rio de la Hacha, eastward of Santa Martha, will produce nearly half the effect of an equal quantity of Brasil wood, and sell proportionably dear; and it is this sort which they distinguish by the name of stock-fish wood. Dampier mentions another variety, called *blood wood*, growing

about the gulph of Nicaragua, and similar, as he thinks, to camwood.

The way of employing the Nicaragua wood, and the mordants used with it, differ so little from those which are thought most suitable for Brasil wood, that any particular explanations on this subject would be superfluous.

ARTICLE IV.

Cæsalpinia Brasiliensis, or smooth-leaved Brasiletto.

This is the pseudo santalam croceum of Sir Hans Sloane, (Jam. ii. p. 184,) and the first cæsalpinia of Brown, commonly called Jamaica brasiletto, or Jamaica red wood. It is one of the cheapest and least esteemed of the red dyeing woods.

ARTICLE V.

Cæsalpinia crista; the Bahama, or broad-leaved prickly brasiletto, of which Catesby has given a description and figure (Carolina, vol. ii. 51.) He adds, "the inhabitants of the Bahama islands formerly got a great part of their subsistence by cutting this wood, but it is now much exhausted." I have mentioned the wood of this and the preceding article as belonging to different species of cæsalpinia, on what is deemed the best authority, but their distinctions do not seem to have been well ascertained, and I think it very probable, that they are but varieties of one species. Both are commonly employed for dyeing inferior and fugitive red colours, upon the aluminous basis.

ARTICLE VI.

Camwood.

This was first brought to Europe from Africa by the Portuguese, who called it *pao-gaban*, or *gaban* wood,

having found it near the river of that name. Finch afterwards mentioned it as growing near Sierra Leone, and being there called *kambe;* whence, by abbreviation, the name of cam, or kam, has been formed. It appears to be the heart of a tree, which bears legumes, and is nearly related to the genus cæsalpinia, and which professor Afzelius has lately made the foundation of a *new* genus, with the name of *tespesia.*

This wood affords a red colouring matter, differing but little from that of the ordinary Nicaragua wood, either in quality or quantity; and it may be employed with similar mordants.

ARTICLE VII.

Barwood.

This is another African production, imported subsequently to the former, and principally from Angola. It does not appear to contain any tannin. Upon the aluminous basis, it gives yellowish brown reds to *wool* and cotton, of considerable durability on the former, though rather fugitive on cotton. This colour may be saddened and varied, by employing solutions of iron or copper with it, either alone or conjointly with alum. The dark red, which is commonly seen upon the British imitations of Bandæna, or East India silk handkerchiefs, is commonly produced by the colouring matter of barwood, saddened by sulphate of iron; and being so saddened, it is now very much employed to give dark grounds for *deep blue* colours, dyed with indigo, and thereby produce a saving of the latter. It commonly bears about half the price of camwood. I have not been able to obtain any accurate information concerning the tree which affords this wood. An inferior sort of it is imported from Old Calabar.

Mr. Clarkson has stated, that an African wood vessel,

brought home accidentally among her barwood, a small billet of a superior colour to the rest; that one half of it was cut away for experiments, by which "it was found to produce a colour that emulated the *carmine*, and was deemed so valuable in the dyeing trade, that an offer was immediately made of sixty guineas per ton, for any quantity that could be procured." He has added, that the other half of this billet was "sent back to the coast, as a guide to collect more of the same sort;" but with what success, I know not.

ARTICLE VIII.

Red Saunders.

The wood brought from Coromandel, under this name, (pterocarpus santalinus,) is employed to dye lasting reddish brown colours upon wool, though but a small portion of its colouring matter is soluble by water alone; and even when assisted by potash, or soda, the solution is incomplete; this difficulty may, however, be in some degree overcome by employing the rasped wood with sumach, galls, or the rinds of walnuts. Broadcloth, prepared (as usual) with alum and tartar, being boiled in water with equal portions of ground sumach and rasped saunders, was dyed of a very bright and lasting reddish orange. In several experiments, I found a diluted sulphuric acid to act very efficaciously in extracting the colour of this wood.

Vogler gave, as he asserts, a colour to wool almost equal to scarlet, from this wood, after extracting the colouring matter by spirit of wine; but this menstruum would prove too costly in Great Britain for this use.

CHAPTER VI.

Of Logwood.

Or "what Campeachy's disputable shore
Copious affords to tinge the thirsty web."

DYER'S FLEECE.

THE tree producing this wood, is the *hæmatoxylon** Campechianum, (Linn.), with crooked spinous branches, leaves abruptly pinnate, leafets inversely heart-shaped, and flowers racemed; the latter are succeeded by small flat lanceolate capsules, about two inches long, and containing each five or six small flat seeds. Like the genus cæsalpinia, it belongs to the natural order of lomentaceæ, and the leguminosæ of Jussieu.†

* The name of hæmatoxylon is formed of two Greek words, signifying *blood wood.*

† Both Sloane and Catesby have described and figured this tree, which grows so rapidly, that in four years after the seed has been planted, the stem often acquires its greatest circumference, which is about two feet. Dampier says, "when the old tree is cut, the sap is *white*, and the heart *red;* the last being only used for dyeing, they chip off all the white sap before they carry it on board." It commonly grows, and is supposed to thrive best, in a wet soil, with a large proportion of clay. The bark of the branches, and of the very young trees, is light-coloured and smooth; but that on the stems of the old trees, is rough and dark coloured. Hitherto the bark has been all thrown away, though, from some few experiments which I have made with it, I am convinced it might be usefully and profitably employed in dyeing, though its colouring matter differs greatly from that of the wood. The younger trees are most thorny. Dr. Robertson (Hist. of America, vol. iii. p. 235, 8vo.) says, "the logwood produced on the *West Coast of Yeucatan*, near the town of St. Francis, where the soil is drier, is in quality far superior to that which grows on the marshy grounds, where the English are settled." Dr. Robertson has here adopted an opinion, which the Spaniards have endeavoured to propagate, in order that the logwood which, since the peace of 1783, they have allowed to be imported,

This tree has been transplanted from Campeachy and Honduras, to most of the West India islands. Sir Hans Sloane mentions Mr. Barham as having brought the seeds from the former of these places, in 1715, to Jamaica, where it now occupies many large tracts of ground, particularly in the neighbourhood of Savanna-la-Mar.

The Spaniards first became acquainted with this wood, and gave it the name of *palo* Campechio, whence it was called *campeche* wood, by some of the first English writers, by whom it was mentioned, particularly Chilton, Parker, and Middleton (in the collections of Hackluit and Purchas.) But in the voyage of the Earl of Cumberland, it was soon after mentioned under the name of *logwood*, which name seems to have prevailed in this country over the former, as that of bois d'Inde* has among the French, over the appellation of bois de Campeche, which they also first gave it.

Logwood seems to have been first brought to England, soon after the accession of Queen Elizabeth, but the various and beautiful colours dyed from it, proved to be so fugacious, that a general outcry against its use was soon raised, and an act of parliament was passed in the 23d year of her reign, which prohibited the use of it as a dye, under severe penalties; and not only authorised, but directed the *burning* of it, in whatever hands

free of duty, from *Campeachy*, might obtain a preference in the market, over that of *Honduras*, cut by the English; but I do not find it to be well founded.

* This name of *bois d'Inde*, seems to have misled Berthollet to suppose, (tom. ii. p. 243,) that the Jamaica pepper, pimento or allspice, (obtained from the myrtus pimenta,) and the logwood, were produced by the *same tree;* Dutertre, Rochefort, and others, having early distinguished that species of myrtle, or, perhaps more strictly, the *myrtus acris*, by the name of *bois d'Inde*, which it still bears at Martinico, and other French West India islands.

it might be found within the realm; and though this wood was afterwards sometimes clandestinely used, (under the feigned name of black-wood,) it continued subject to this prohibition for nearly one hundred years, or until the passing of the act of the 13th and 14th of Charles the Second; the preamble of which declares, that "the ingenious industry of modern times, hath taught the dyers of England the art of fixing the colours made of *logwood, alias blackwood*, so as that, by experience, they are found as lasting as the colours made with *any other sort of dyeing wood whatsoever;*" and on this ground it repeals so much of the statute of Elizabeth as related to logwood, and gives permission to import and use it for dyeing. Probably, the solicitude of the dyers to obtain this permission, induced them to pretend that their industry had done much more than it really had, in fixing the colours of logwood; most of which, even at this time, are notoriously deficient in regard to their durability.

Six quarts of distilled boiling water, may be made to extract nearly all the colouring matter of one pound of logwood properly chipped, and when so extracted, the decoction will be yellow, with a sweetish taste, and will contain, in addition to the colouring matter, a volatile oil, with small portions of lime and potash, in union with acetic acid, besides some other matters of no importance, in regard to its effects in dyeing. Tannin has been generally considered as one of the constituents of an aqueous extract of logwood, but without reason, as the infusion or decoction when recently made, does not coagulate or precipitate a solution either of glue or of isinglass; and the appearance of such precipitation, which is sometimes produced, results from a subsequent absorption of oxygene, for which the colouring matter of logwood has, whilst moist, a strong attraction.

If the decoction be made with common, instead of distilled water, it will exhibit not a *yellow*, or an orange, but a full red or dark blood colour, by reason of either the selenite, or the calcareous earth which such water generally contains; but by adding to it sulphuric, nitric, or muriatic acid, the yellow will be restored, and a subsequent addition of any of the alkalies, in a proportion sufficient to supersaturate the acid, will re-produce the purple colour.

When logwood is of good quality, it will yield from one fifteenth to one twentieth of its weight of *pure colouring matter*, which will be soluble in alcohol and in water, if the decoction, after being made, has been speedily evaporated to a dry state by fire; but if an interval of several weeks is allowed previously to intervene, or if the evaporation be slowly performed, by exposing the decoction to the sun and air, even in summer, or in a hot climate, the colouring matter will absorb and combine with a large proportion of oxygene, and become, in a great degree, insoluble by water, and the colours dyed from it will prove much more *fugitive* than those produced by the decoction when recently made.* A circumstance in which it differs greatly

* I found this to be the case of a large parcel of an extract of logwood, which had been prepared in the West Indies, merely by exposing an infusion or decoction of the wood to the sun's rays; it had a fine bright glossy aspect, produced by very small crystals; but a large proportion of it was nearly insoluble by water, and the colours dyed with it were uncommonly fugacious.

Having formerly attempted to substitute the dry extracts of various dyeing drugs, for the drugs in their natural state, in order to diminish the expense of freight, &c. and such attempts having, in almost every instance, been attended with disappointment and loss, by reason of the changes to which colouring matters are liable, by the operations necessary for their extraction and evaporation, it be-

from the colouring matter of Brasil wood; which last, probably might, with greater advantage than almost any other, be brought into the form of an extract, (for the use of dyers,) at the place of its growth, to diminish or obviate the expense of transporting the wood to a sea-port, and its subsequent freight to Europe. This strong attraction of the colouring matter of logwood for oxygene, may, perhaps, be a cause of the want of permanency in the colours dyed with it, though we find an equal want of permanency in those obtained from the Brasil wood, whose colouring matter combines but slowly with oxygene, and is benefited rather than injured by such combination, as is indeed the case of many other colouring matters.*

comes me to recommend caution to those who may be disposed to engage in similar undertakings.

* M. Chevreul supposes, that the extract of logwood contains *two sorts* of colouring matter, one, which he calls hæmatine, which is susceptible of crystallization, and soluble both by water and by alcohol, giving them a reddish orange colour, and the other denominated by him, "matiere d'un rouge maron," which is not soluble by water. This last he considers as possessing most of the properties of those vegetables which are called astringent, and especially that of causing a precipitation of gelatine. I am persuaded, however, that this insoluble matter, which occurs only after the colouring matter has been evaporated to dryness, is merely the product of a combination of oxygene, with a portion of that which he calls hæmatine. I have found repeatedly that a decoction of logwood, after being kept five or six weeks in hot weather, lost the sweetness, and acquired the very properties which he ascribes to his "matiere d'un rouge maron," including that of precipitating a solution of isinglass. But this precipitate differs from that produced by the tanning principle, because *it is soluble in boiling water*, which that of *tannin is not;* and this single fact proves, that the precipitation *which does not take place with a recent decoction* of logwood, results from a subsequent change, and a newly-acquired property, differing essentially from that of the tanning principle. For the rest, M. Chevreul admits, that the supposed two sorts of colour-

By adding a sufficient portion of alum to a decoction of logwood, the colouring matter may be *all* made to unite with the alumine, and form a purple or reddish violet compound, separable by the filter so completely, that the water will run from it colourless. When not filtered, a great part of the compound will subside, but not the whole, unless an alkali be added. By employing a sulphate of iron instead of alum, a similar combination will take place, and a bluish black colour will be thereby produced. All the solutions of tin produce purple or violet colours with the decoction of logwood, and a complete precipitation of the colouring matter. Solutions of the other metals and earthy bases will also combine with the colouring matter of logwood in different proportions, and with different degrees of affinity, producing various colours and precipitates, to be noticed hereafter. Sulphate of copper added to the decoction of logwood, gives it a purplish blue colour; sulphate of pure zinc added to a similar decoction, produces a dark purple; nitro-muriate of gold, an orange; muriate of quicksilver, an orange red; muriate of antimony, a beautiful crimson; acetate of lead, a garter blue; arseniate of potash, a deep yellow; muriate of barytes, a reddish purple; nitrate of barytes, a brownish purple; strontia earth, a violet; sulphate of magnesia, a purple; muriate of magnesia, a yellow; sulphate of lime, a purple; and muriate of lime, a violet purple. These effects show that the tingent matter of logwood, is capable of producing, with different mordants or bases, almost all the possible varieties of colour.

Sulphuretted hydrogene gas, produces a disappearance

ing matter are both attracted by the same bases, and applicable in dyeing with the same mordants. See Ann. de Chimie, tom. 81 and 82.

of the logwood colour, like that which it occasions to the colour of Brasil wood, and, undoubtedly, in the same way, i. e. merely by combining with it, and not by any deoxygenating effect.

Wool dyed with a decoction of logwood in hard water, obtained a purple colour, which, by exposure to the sun and air, speedily changed to a drab colour; and this last afterwards manifested considerable stability.

Chips of logwood being put into water, acidulated by sulphuric acid, and boiled therein, produced a brownish yellow decoction; and wool dyed therewith obtained a strong yellowish bright snuff colour, which, being exposed to sun and air during five weeks, manifested considerable stability.

Nitric acid being mixed with a decoction of logwood, produced a fine bright yellow. But this, by boiling, gradually became a yellowish brown, and communicated that colour to wool dyed therein; which being sufficiently exposed in the open air, proved to be a lasting colour.

Woollen cloth being boiled during one hour in water, with a suitable portion of sulphate of lime, and afterwards dyed with logwood, acquired a full and bright, though brownish, orange, which proved lasting.

Cloth boiled with a decoction of logwood in water, slightly acidulated by muriatic acid, took a brownish yellow colour.

Cloth boiled with muriate of lime, and dyed with logwood, took a brownish orange colour, which, however, did not prove sufficiently durable.

Wool dyed with logwood and sulphate of magnesia, received a yellow colour, but it proved very fugitive.

Woollen cloth prepared with alum and tartar, as usual, being dyed with logwood, obtained a bright violet colour, which, by adding a little muriatic acid to the dye-

ing liquor, may, as I have found, be made to incline more to the red or purple, but neither of these colours have the desired stability; though the former is not unfrequently employed.

The best and least fugitive of the purple or violet colours obtained from logwood, are produced by mordants principally composed of solutions of tin: one of these became very fashionable in France, about thirty years ago, under the name of *prune de Monsieur;* and being then resident at Paris, I wore a coat of this colour, without having had any reason to complain of it as being fugitive. Of the invention and composition of this colour, an account given by M. Descroizilles, (a chemist at Rouen,) to M. Berthollet, was published by the latter, in the first edition of his Elements, &c., from which it appears, that M. Giros de Gentilly was the first who attempted successfully in France, to introduce the dyeing with logwood and a solution of tin. His first trials were made at the dye-house of Messrs. Petou and Frigard; but he suffered so much to transpire, respecting the composition of his mordant, that M. Decroizilles was soon able to produce a tolerable imitation of it, by making a solution of tin with sulphuric acid, to which he added muriate of soda (sea salt) with acidulous tartrite of potash and sulphate of copper; and this composition answered so well, that M. Giros was induced to form a partnership with M. Decroizilles, to obviate the loss which was likely to result from a competition with him. When this association had taken place, M. Giros taught his new associate a more convenient method of preparing the mordant in question, which was by dissolving the tin in a mixture of sulphuric acid and sea salt, with a suitable proportion of water, to which the tartrite of potash and sulphate of copper in powder were added afterwards. Of this mor-

dant they made at the rate of 1500 quarts daily, in a single leaden vessel; and continued to prepare and sell this composition with great profit, (at 30 sols the pound,) during three years, after which, their sales gradually decreased, until they thought it proper wholly to relinquish the undertaking; the indiscretion of M. Giros, concerning the composition of his mordant, having produced other imitators, whose compositions, though at first defective, were afterwards preferred to that of the original inventor.

To dye unspun wool with this mordant, the latter was employed in the proportion of one third of the weight of the wool, but for cloth or woollen stuffs one fifth was deemed sufficient; and being mixed in a tin dyeing pan or vessel, properly supplied with water, the wool or cloth was made to imbibe the mordant, by the usual treatment during two hours, and being afterwards rinced, it was dyed in a fresh bath, with logwood; but as the latter, if employed alone, would produce a violet colour, a portion of Brasil wood was added, to make it partake more of the red, and afford that which was called *prune de Monsieur*.

This colour was, indeed, liable to some alteration, if sent to the fulling mill, by the soap and urine there employed; but the alteration was afterwards easily overcome, and the proper colour restored by passing the cloth or stuff through warm water, slightly acidulated by sulphuric acid.

M. Decroizilles asserts, that wool dyed with this mordant was susceptible of being spun with greater evenness, and extension or fineness, than wool dyed with alum; that an omission of the sulphate of copper rendered the fibres of the wool harsh, and impoverished the colour.

M. Berthollet supposes, that in this composition the

sea salt was decomposed by the sulphuric acid, and that the muriatic acid being set at liberty dissolved the tin, of which a part was afterwards precipitated by the acid of tartar. That the oxide of copper formed a blue, with a part of the colouring matter of the logwood, and the oxide of tin a violet with the remaining part, and a red with that of the Brasil wood.

Before the commencement of M. Decroizilles' partnership with M. Giros, I had begun to occupy myself with experiments for fixing the colours of logwood and Brasil wood by different solutions of tin, and I have since, at various times, renewed and repeated these experiments with considerable success. I had, at a very early period, discovered the highly important influence of tartar in giving stability to the beautiful yellow produced upon wool or woollen stuffs from the quercitron bark, by solutions of tin; and I was induced, by that discovery, to try the effect of tartar with the basis of tin, in fixing the logwood purple, or violet colour, upon the same stuffs; and I have repeatedly found it more efficacious with that basis, than any other means for enabling this colour to resist the impressions of sun and air. I am, indeed, persuaded that the principal merit of the mordant employed by M. Giros, results from the tartar which it contains conjointly with the tin. The sulphate of copper may, indeed, contribute to obviate the harshness which is commonly given to wool by the oxide of tin, and may give a particular tone to the colour; but it certainly cannot render it more durable than it would be with the oxide of tin and tartar in suitable proportions; and if a full proportion of the latter be employed, any of the solutions of tin will, I think, answer the purpose; though the murio-sulphate, as being cheapest, may deserve a preference.

M. Dambourney, who (as I lately mentioned) has

represented the bark of the white birch, betula alba, to be highly efficacious in fixing the colour of Brasil wood, with a nitro-muriate of tin, ascribes to it a similar effect in regard to the colour of logwood, with the same basis; adding, that it moreover changes the colour of the latter to a blood red.

With nitro-muriate of bismuth, employed as a mordant upon wool, logwood produced a bluish violet colour, which being condensed by a protracted boiling, became a very full and durable black.

Wool, prepared with sulphate of zinc, and dyed with logwood, obtained a violet colour, which proved fugitive.

Wool, prepared with muriate of antimony and dyed with logwood, became of a snuff colour, which was tolerably permanent.

Wool, and broadcloth, prepared by boiling with a diluted nitrate of lead, being afterwards dyed with logwood, obtained a deep blue colour, which soon faded by exposure to the sun and air;—nearly similar effects were produced by substituting the acetate, for the nitrate, of lead.

Wool or cloth, dyed with logwood, and either sulphate of copper or verdigrise, obtains a blue colour, which is, however, neither bright nor durable, though the cheapness of the matters producing it, has caused the use of it to be very frequently and generally adopted; sometimes for stuffs of little value, and at others, to give more fulness or intensity to the blue from indigo, and produce a saving of the latter. Indeed, the excessively high price at which indigo has been sold upon the continent of Europe for several years last past, has there, according to my information, occasioned a very general substitution of logwood, for the purpose just mentioned, and particularly in France.

To produce the logwood blue, Pœrner recommends half as much sulphate of copper as of the logwood, to be employed; but from the results of my experiments, I conclude that a smaller proportion of the former will suffice. The blue dyed by these means commonly inclines to a greenish tint, perhaps, because the oxide of copper becomes green, by a farther absorption of oxygene or of carbonic acid.

Broadcloth dyed with logwood, and one-fifth of its weight of sulphate of copper, and half as much lime, acquired a dark greenish blue, which, after one month's exposure to sun and air, manifested more stability than the blue commonly dyed from logwood. By substituting cream of tartar for the lime, a dark and lasting tobacco brown was produced.

The greatest consumption of logwood results from its use in the dyeing of *black*, especially on wool and woollen cloths or stuffs; but this use of it will be particularly noticed in a subsequent chapter, which I shall appropriate to that colour.

In regard to silk, logwood (besides the black) is employed to give it a violet colour, after it has been alumed as usual; and it is moreover employed as lately mentioned, to give it the colour, which in France is called prune de Monsieur. To produce this colour, however, Fabroni has recommended a mordant, prepared by combining the muriate of tin with sulphate of copper and tartar, and employing a small proportion of galls, or of alder bark, with the logwood, in the dyeing liquor.

Berthollet has observed, that silks which had been impregnated with solutions of tin at different degrees of oxidation, being afterwards dyed with logwood, he found that the best effects were produced on those to which tin, the *least* oxygenated, had been applied.

The colouring matter of logwood has so much less

affinity for linen or cotton, than for wool, that it will not attach itself to either of them without the aid of some earthy or metallic basis: but with some of these bases they may be made to receive from it colours nearly resembling those which wool obtains by the same means, excepting the circumstance of their being generally a little more fugitive on the former than upon wool: but this defect may be, in a considerable degree, obviated, by employing a portion of galls with the logwood.

I have attempted, at different times, to give some tolerable degree of permanency to the colouring matter of logwood, applied *topically*, or prosubstantively, to calico, in combination with almost all the known mordants or bases; and, on looking over the notes which I made of my different experiments, the following results seem to be most worthy of notice.

A strong decoction, containing the colouring matter of one pound of logwood, being placed over the fire with half a pound of alum in powder, and gum of Senegal, sufficient to thicken it properly, and these being dissolved and well mixed, and the mixture being applied topically by the pencil to calico, a bright, though darkish, purple colour was produced, which resisted several washings, and a fortnight's exposure to the weather, without much injury. By substituting the acetate of alumine for common alum, effects a little better were produced.

By substituting the muriate, nitro-muriate, and muriosulphate of tin, for alum, brighter colours were produced, which resisted the action of soap and strong French vinegar, and were not much hurt by several weeks' exposure to the sun and air. Phosphate of tin, employed in the same way, produced a bright red colour.

The nitro-muriate of cobalt, employed in the same way, produced with logwood a bluish purple, a little

more fugitive than the preceding. Nitro-muriate of antimony, employed in the same way, produced a colour nearly similar to the last.

The nitrates of silver, lead, and zinc, all produced purple or violet colours, but they were more fugitive than those with solutions of tin. The nitro-muriate of nickel, produced with logwood a glossy bright colour, like that of Vigonia wool.

The nitrate of copper, being partly neutralized by ammonia, produced, with the decoction of logwood, a dark blue of considerable durability. A brighter blue, and more useful for topical application, may, however, be obtained, by substituting the sulphate of copper, and partially neutralizing its acid, either by ammonia, potash, or soda, or which is, perhaps, better, by an ammoniate of copper, as formerly mentioned. I have already noticed, at pp. 159 and 160 of this volume, the good effects of this logwood blue, in combination with a prosubstantive yellow from quercitron bark, in producing a green colour for topical application.

In my arrangement of the adjective colouring matters, I thought it most natural, first to notice the three simple or primitive ones, from which all the others may be compounded, and to begin with the yellow, as being the least removed from white, then proceed to the red, and afterwards to the blue; and it was from a regard to the property which logwood possesses, of producing a *blue* colour with the basis of copper and that of lead, that I have been induced to place it subsequently to the Brasil, and other woods affording *red* colouring matters. This, then, would be the proper place for me to mention any other adjective colouring matters, capable of producing the *blue*, if any such were known, and ascertained to be worthy of being employed by the dyers of Europe. But this, I believe, is not the case.

Loureiro has, indeed, mentioned (tom. i. p. 241) the polygonium tinctorium, a perennial plant, growing about Canton, in China, as being employed to dye a fine blue and green, "ad tingendas telas pulchro colore cæruleo aut viridi;" and Thunberg mentions the people of Japan as cultivating, for the same purpose, three other species of polygonium, viz. p. chinense, p. barbatum, and p. aviculare. But with what bases or mordants these are employed, we are not informed.

Brown, also, in his History of Jamaica, p. 143, mentions the randia aculeata, (now considered as a species of *gardenia,*) called Indigo-berry on that island, as affording berries which, when ripe, "stain paper or linen of a *fine fixed blue colour*, which stands either soap or acids." I lately requested my son (now in Jamaica) to send me some of these berries, which he promised to do when the season in which they become ripe should arrive; but not having as yet received any of them, I can add nothing from my own knowledge concerning their use. The wood of the guilandina moringa, or horse-radish tree, and the roots of mercurialis perennis, or dog's mercury, are also said to yield a blue colour; but in the latter at least, it probably has no stability. The bark of the fraxinus excelsior, and the berries of the empetrum nigrum, or black-berried heath, are also said to produce a blue colour, by Jorlin (in a paper, contained in the Amœnitat. Academiæ.)

CHAPTER VII.

Of Vegetables affording adjective Brown, and other mixed colouring Matters; including the Fawn, or Fauve Colour of the French.

"Un physicien qui veut prendre quelque connoissance de l'art de là teinture, est, pour ainsi dire effrayé par la multitude des objets nouveaux que cet art lui presente."

HELOT. ART DE LA TEINTURE DES LAINES, &c.—*Preface.*

ARTICLE I.

Of the bark of the Rhizophora Mangle, or Mangrove Tree.

THIS is one of three vegetable colouring matters, of which, in consequence of my discovery of their properties, the use was exclusively vested in me for a term of years, by an act of parliament, as lately mentioned; and the tree producing it grows abundantly on nearly all the sea-coasts between the tropics, *round the globe*, and s eminently remarkable for the singularity of its propagation, not only by seeds, which *germinate* downward several inches, while actually adhering to the branches of the tree,* but also by a great number of long round appendices, which, like ropes of different lengths, constantly shoot down from the under sides of most of the branches to the earth, and taking root in the mud, each becomes at first a fulcrum or prop, to support the parent tree against the impetus of the tides and waves of the ocean, and afterwards forms the stem of another tree, which propagates itself in like manner; so that impassable forests are formed, extending many leagues, and nearly all the trees composing it are connected

* Whence its generic name of rhizophora, from two Greek words, which signify root bearing.

with each other, either by their branches or their roots, of which many, by extending horizontally upon the surface of the earth, arrest and accumulate great masses of earthy and vegetable matters, and thus enable the land constantly to encroach upon the sea, and produce that vast extent of *alluvial* grounds which has been formed within the tropics.

Oviedo, Clusius, De Laet, and other early writers, have mentioned this tree by the name of mangle, which it bore among the natives of Hispaniola; Linschoten gave it the name of arbor de raiz; and Rochefort, that of paretuvier, or paletuvier, which it retains among the French; whilst the Dutch call it *duizen-beenen*, or thousand legs, from its numerous props or supporters.

There are two varieties of this species of rhizophora, one of which is called the red, and the other the *purple or violet* mangrove; and the barks of both are nearly half an inch thick, of a reddish brown colour, and replete with colouring matter and *tannin;* both of which may be nearly all extracted by water employed in a sufficient quantity.

Wool, or woollen cloth, prepared as usual with alum and tartar, and dyed with only one-twentieth of its weight of powdered mangrove bark, acquires a bright, full, and lasting annotta, or reddish, though somewhat brown orange colour. The solutions of tin, employed as mordants, do not considerably raise or improve the colour of this bark upon wool; though they produce what Dambourney calls, "un mordoré solide."

By substituting the sulphate of iron for alum, wool or cloth will obtain from the mangrove bark, a lasting chocolate brown colour, much darker than the same means will produce upon linen or cotton; and by employing with the sulphate of iron, one-sixth of its weight of carbonate of lime, a very dark and durable drab, or

slate, colour will be produced. Sulphate of copper, instead of sulphate of iron, produces, with the same means, a permanent cinnamon brown.

The natural colour of the mangrove bark, or that which it communicates to linen and cotton upon the aluminous basis, is a kind of salmon, or reddish nankin colour, for which it has hitherto been chiefly employed in this country, particularly at Manchester. Probably the cheapest and best mordant for this colour is made by dissolving eight pounds of alum with one pound of clean chalk or whiting, in six gallons of water; in which, after the solution is effected, the cotton may be soaked twelve hours, then dried, and afterwards dipped into lime water; drying it again, and then soaking it a second time, for about five minutes, in the solution of alum; after which, being well dried and moderately rinced, it may be dyed with about one-twentieth of its weight of the mangrove bark in powder, adding a little when the colour is sufficiently raised.

By substituting the sulphates of iron and copper, as mordants, as well as by mixing them with alum, a great variety of brown, olive, and drab colours may be cheaply dyed from the mangrove bark, upon fustians, cotton, velvets, &c., which will prove more lasting, and much less susceptible of accidental spots and discolorations than similar colours, commonly dyed from the morus tinctoria, &c.

The mangrove bark may be employed by the calico printers for dyeing pieces printed with the acetates of alumine and of iron, upon which it will produce reddish orange and slate colours, without considerably staining the white grounds. This bark will also afford several prosubstantive colours, applicable by the pencil, and of considerable durability.

One of these, a salmon or reddish cinnamon colour, may be made by mixing a very strong decoction of the mangrove bark, with the acetate of alumine, and afterwards thickening the mixture as usual; and this may be improved by adding to it a little nitro-muriate of tin; or which is better, a murio-tartrite of that metal.

A similar decoction of this bark, mixed with the acetate of iron, will produce a lasting prosubstantive dark drab, or slate, colour.

ARTICLE II.

The Rhizophora Gymnorhiza,

Is another species of this genus, producing very large trees, which cover an immense tract of sea-coast along southern shores of Cochinchina and Cambodia, as well as in the Straits of Malacca; and is supported by numerous and widely spreading arcuated roots, which are generally overflowed by the tide at high water. Loureiro says, the thick reddish brown bark of this tree is highly useful in dyeing rufous, or chesnut colours, which are easily converted to black, by alternately dipping the cloth (probably cotton) into a decoction of the bark, and then into a mixture of dark brown mud and water, then drying and repeating the dippings, until the desired colour is obtained;* and this black he represents as permanent. The mud employed for this purpose, doubtless, contains an oxide of iron; but if this will render the colour black, there must, in that respect, be a considerable difference between the colouring matters of this, and the former species.

* "Utilissimus est ad tingendos telas colore rufo vel castaneo; qui facile in nigrum mutatur, si alternis vicibus immergantur telæ cœno fusco aqua diluto," &c.—Cochinchina, tom. i. p. 297.

ARTICLE III.

The Bark of the Mahogany Tree, (Sweitenia Mahogani,)

Possesses colouring matter, so nearly similar to that of the mangrove, that no additional explanation can be wanted respecting the effects which it produces with different mordants, or the methods of applying it for dyeing, excepting only the circumstance of its affording about one-third less of colouring matter, than an equal weight of mangrove bark.

ARTICLE IV.

The Bark of the Acer Rubrum, or Scarlet Flowering Maple of North America, (described and figured by Catesby, tom. i. p. 62,)

Produces a very lasting cinnamon colour with the aluminous basis, not only on wool but on cotton; and with the sulphate, or the acetate of iron, it communicates to both, a more *intense*, *pure*, and *perfect black*, *than even galls*, or any other vegetable matter within my knowledge; and it has the advantage, in calico printing, of not only not staining the white grounds, but of obviating (like the d'howah, lately mentioned) the stains which some other colouring matters would produce without it. The leaves of this species of maple produce effects nearly similar to the bark.

ARTICLE V.

American Oaks.

I have made experiments with nearly all the twenty species of American oaks, described and figured by the elder Michaux, and they have all, excepting the quercitron oak, and some few varieties possessing similar properties, appeared to contain large proportions of a co-

louring matter which, with the aluminous basis, produces cinnamon browns, and with that of iron, blacks, more or less perfect.

ARTICLE VI.

Pinus Abies Americana, or Hemlock Spruce.

The bark of this tree, which is employed in Nova Scotia to tan leather, affords a colouring matter which, with an aluminous basis, produces a lasting bright reddish brown colour upon wool, and a nankin colour on cotton, which, however, on the latter, is a little deficient in durability. With either sulphate, or acetate of iron, this bark produces dark drab and slate colours; but not a black.

ARTICLE VII.

Juglans Oblonga Alba, or North American White Walnut, commonly Butternut.

In Dr. Birch's History of the Royal Society, it is stated that this learned body received, on the 10th of February, 1669-70, from Mr. Winthrop, one of the Fellows, some stuff, manufactured in New England from a mixture of cotton and wool, and sent by him "to show the colour, which was only dyed with the bark of a kind of walnut tree, called by the planters butternut tree, the kernel of that sort of walnut being very oily, whence they are called butternuts. They dyed it only with a decoction of that bark, without alum or copperas."

I have been, from a very early part of my life, acquainted with this tree, and have made numerous experiments with its bark, the colouring matter of which, has, indeed, so much affinity with wool, that, without any mordant or basis, a decoction of it will dye woollen stuffs of a durable tobacco brown, which may, however,

be improved, both in brightness and permanency, by an aluminous basis; and this last is necessary to fix this colour upon linen or cotton. With either the sulphate or acetate of iron, this bark communicates to wool, linen, and cotton, a strong and lasting black colour; and calicoes printed with the acetates of alumine and of iron, separately, and also mixed, being dyed with this bark, will receive various shades of brown, drab, and black colours, sufficiently permanent, and without any stain or discoloration of the white grounds; a decoction of this bark, in which a little gum arabic had been dissolved, having, in the course of my experiments, been mixed with a solution of iron by nitric acid, the whole was *instantaneously converted into a solid blackish mass,* which required considerable trituration in a glass mortar, with hot water, to divide and render it soluble again. I repeated the experiment afterwards, with a similar effect; though nothing like it was produced by any other metallic nitrate, of which I mixed several with a similar decoction of this bark. The rinds of the nuts of this tree possess the same colouring matter as the bark; and both afford an extract, which is much esteemed in the United States of America as a mild cathartic.

ARTICLE VIII.

The Juglans Nigra Oblonga, or Oblong-fruited Black Walnut of North America,

Affords, by its bark, and the rinds of its nuts, a dark brown colouring matter, which, on the aluminous basis, communicates to wool and cotton a sort of durable tobacco, or chesnut brown; and with solutions of iron, a brown considerably darker; my experiments, however, with this vegetable, have been but few. Dambourney says, that with a nitro-muriate of bismuth, it gave to wool a very lasting puce, or flea colour.

ARTICLE IX.

The Juglans Regia, or Common Walnut,

Affords in the rinds of its nuts a colouring matter, which, though naturally almost limpid, changes to a dark brown by exposure to atmospheric air, whence it probably absorbs oxygene; of this change proofs are in the autumn frequently seen, upon the hands of those who employ themselves in separating these rinds from the nuts. Braconnot, from a series of experiments upon these rinds, infers, that they contain starch, and an acrid bitter substance, which, by combining with oxygene, becomes carbonaceous; also malic acid, citric acid, tannin, phosphate of lime, oxalate of lime, and potash. He says, the recent juice being filtered, exhibits an ambour colour, but with sulphate of iron changes to a dark, or blackish green.

The colouring matter of walnut-rinds has a decided affinity with wool, and being applied to the latter by dyeing, without any mordant, gives it a brownish cinnamon colour, of considerable durability, though it may be rendered brighter and more lasting by an aluminous basis; but on cotton I have not found it produce very lasting colours, even with that or any other basis.

These rinds are most frequently employed to produce, without any basis, particular shades of brown *or dark* colours, upon wool or woollen stuffs, after having been left to macerate in water, and undergo a sort of putrid fermentation during several months. The unfermented rinds, however, with solutions of copper, iron, bismuth, &c. may be made to communicate very lasting chesnut drab, slate, and other dark colours, to wool or cloth.

ARTICLE X.

The Bark of Alder, Betula Alnus,

Possesses a colouring matter which, with the aluminous basis, dyes a permanent and very full, though brownish yellow, or orange, upon wool, cotton, &c.; and one which is brighter with the solutions of tin. With the sulphate or acetate of iron, it forms a black, and has long been beneficially employed with galls, &c. in forming the black vat for dyeing that colour upon thread and cotton yarn.

ARTICLE XI.

Areca Nuts.

It having been reported that the areca, or Pynang nuts, produced by the areca palm, were employed by the people of Malabar to dye a red colour, I procured and made trial of a parcel of them; but without obtaining any effects which might not be as well procured from many other vegetables, and even from the alder bark, last mentioned. With alum these nuts produced a sort of reddish cinnamon colour, and with iron, a brownish purple black, both of which appeared to be lasting.*

* Sometime after my experiments with these nuts had been made, I found, by looking into Loureiro's Natural History of Cochinchina, (original Lisbon edition, p. 567, et seq.) that I had mistaken their proper use. He mentions this species of palm as being extensively cultivated in that country, for the sake of the nuts, and that the fullers make a decoction from them, and apply it to cloths already dyed, to render their colours more bright and lasting. "Fullones telas quascunque imbuere, ut colores diutius servent, et melius expriment." He adds, that they produce this effect by an agglutinating, and not by an astringent, power, ("vi glutinante, non adstringente,") and that for this use many cargoes were sent annually from Cochinchina to China.

ARTICLE XII.

The Ripe Berries of the Privet, (Ligustrum Vulgare,)

Being employed as a dye, produced, with the aluminous basis, a light apple green, on wool and cotton, and a bluish black colour upon wool. Caneparius mentions tions them, (p. 204,) as having been anciently employed to make ink, and, indeed, they seem to have been the berries to which Virgil, in one of his Eclogues, applied the name of vaccinium;* but Caneparius appears to have mistaken this shrub for that of the hinna, or lawsonia inermis, which Prosper Alpinus had supposed to be a species of ligustrum.

ARTICLE XIII.

The Myrobalan.

This name has been given in the East Indies to the drupaceous fruit, of two species of terminalia, (viz. Indica, and chebula,) as well as to that of the phyllanthus emblica; which last appears to be the myrobalanus of Bontius, and myrobalanus emblica of Loureiro, p. 553. I have already, at p. 260 of my first volume, noticed the terminalia chebula, (which is the terminalia citrina of Roxburgh, or yellow myrobalan of the shops,) and the galls produced on its leaves, as being employed in the East Indies to give a yellow colour on cotton; but I did not include either of these among the adjective yellows of this third part of my work, because, though employed as such in that country, from a paucity of yellow dyes, the colour which they afford partakes so much of a brown tint, as to have but little more right to be deemed a yellow, than that of the alder bark.

* "O formose puer, nimium ne crede colori;
Alba ligustra cadunt, vaccinia nigra leguntur."

Their colouring matter is, however, capable of being rendered highly useful in giving a permanent black with an iron basis, especially upon cotton, as will be seen in the chapter allotted to that subject.*

ARTICLE XIV.

Paraguatan Bark.

The twenty-third volume of the Annales de Chimie, contains the translation of a report given by Dominique Garcia Fernadez, of some experiments which he had made, by order of the supreme council of commerce in Spain, with the bark of a tree growing in the Spanish part of Guiana, and there called paraguatan, or parugatan; which bark he represented as affording a dye in some respects superior to those of madder and Brasil wood, and as being capable of giving to silk, duly prepared, the various shades of rose and red poppy colour, obtained from safflower; and though this gentleman's report did not manifest much knowledge, either of the principles or practice of dyeing in the reporter, I was induced, by the intervention of a friend, to procure some of this bark from Cadiz; but, after several trials, I found myself unable to obtain from it any thing better than a pale salmon colour, too fugitive to be of any value; I, therefore, notice it here, only that I may obviate disappointment, and, perhaps, loss to those who might confide in, and act upon this report.

* A ship bound from Cayenne to France, was captured a few years since with a curious collection of the animal and vegetable productions of Guiana, including a dyeing wood, labelled "*Bois de Sassafras de Cayenne*," which last, the agents for the captors sent to me. It was very heavy, close grained, and of a reddish cinnamon colour; and, consequently, unlike the laurus sassafras. Upon the aluminous basis it dyed a very high orange colour, (which, however, was not lasting upon cotton,) and with iron it gave dark browns.

ARTICLE XV.

Galls.

These are excrescences, produced upon several species of oak, by the cynips quercus, or gall fly, which, by its peculiar structure, is enabled and disposed to deposit its eggs in the young branches, and other parts of the several species of oak, and thereby occasion a protuberance which increases, until the larva of the insect gnaws through its prison or nidus, and escapes, leaving a perforated cavity therein. The galls, so perforated, are commonly of a light colour, and called white galls. Those in which the larva dies, and which have, therefore, no perforation, are commonly called *blue* galls, being of a darker colour, and affording commonly about one-third more of colouring matter, than an equal weight of the white galls.

Until lately the best galls were brought from Smyrna, Aleppo, and Tripoli; but, at present, a considerable part of those which were formerly exported from the two first of these ports, are carried by another direction from the places where they grow to the East Indies, and are thence shipped to this country. Pliny informs us, (lib. xvi. c. 7.) that the galls most esteemed in his time were those of Comagena, and that the least esteemed were those commonly produced upon the quercus robur.

By long boiling, nearly seven out of eight parts of a given quantity of powdered galls may be dissolved in about ten times its weight in water; after which, Newman found that alcohol would only extract four grains from a residuum of two drachms. The solution, so performed by water, besides matters of less importance, contains colouring matter, tannin, and a particular acid, (to which the name of gallic acid has been given,) all intimately combined; though the first, and most important of these

matters, has hitherto been *confounded* with the others. This *colouring* matter precipitates, as I believe, all the metals from their solutions, and the several precipitates, as far as my notes extend, retain nearly the following colours: viz. that of platina, an olive green; that of gold, a greenish brown; mercury, yellow; lead, white or grey; silver, brown; copper, brownish yellow; tin, greyish white; cobalt, pale blue; bismuth, greenish yellow; antimony, bluish white; zinc, a slight greenish brown; nickel, white; columbium, an orange, (according to Dr. Wollaston); osmium, a purple, which changes to a deep blue; and finally, that of iron exhibits a black, which, being diluted, or thinly spread, inclines, more or less, to blue or purple, according to the degree of acidity in the solution whence the precipitation is effected. This *last*, is the most important and remarkable property of galls; and as many opinions, which to me seem erroneous, have been inculcated respecting it, by the highest authorities, and generally adopted, I shall, in a succeeding chapter, endeavour to ascertain the truth in regard to this subject. Here it only remains for me to notice the light cinnamon fawn, or fauve, colour, which galls (like many others of vegetables mentioned in this chapter) afford, particularly to cotton upon the aluminous basis; and which enables them, as I have found by repeated experiments, to communicate by dyeing a durable nankin colour to calico or to cotton yarn, after the latter has been macerated in milk, then dried, and soaked in a saturated solution of alum, with one-eighth of its weight of lime, afterwards rinced, and dried, previously to its being dyed in a decoction of this vegetable. A diluted nitrate of lead employed instead of the solution of alum, produces a similar and equally durable colour.

I will observe here, as I shall have no other opportunity of doing it, that some few vegetables, particu-

larly the Peruvian bark, that of the cherry tree, and that of the horse chesnut, (œsculus hippocastaneum,) possess the property of producing a greenish olive colour with sulphate of iron; a property which M. Braconnot ascribes to a portion of phosphoric acid, which he found them to contain, conjointly with a yellow colouring matter.—See Ann. de Chimie, tom. 70, p. 290.

Pœrner asserts, that chamomile flowers, with sulphate of copper, will dye wool of a durable green colour, and that fenugree seeds will produce a colour nearly similar, with the same basis.

EXPERIMENTAL RESEARCHES

CONCERNING THE

PHILOSOPHY

OF

PERMANENT COLOURS.

PART IV.

Of Compound Colours.

IN treating of the several colouring matters noticed in the former parts of this work, I have most frequently mentioned the applications of which their *simple* colours are susceptible, in order to form what are justly denominated *compound* colours; because (unlike the former) they may be composed by separate mixtures, of two of the three primitive ones, yellow, red, and blue; yellow and blue forming a green; yellow and red, an orange; and red with blue, a purple, or violet, according to the proportions in which they are mixed; whilst *black*, though in *dyeing upon wool* it may be produced by a very great accumulation and condensation of the blue alone, (as an orange may, by the like accumulation of yellow,) is often a compound *of all the three primitive colours.*

But, notwithstanding the mention which I have thus made of the compound colours on different occasions, it seems expedient that I should advert to some of them

more particularly, before this work is brought to its conclusion.

In dyeing compound colours, the matter which affords one part of the compound, will commonly fix itself upon the stuff to be dyed in parts not occupied by the other component colouring matter; but this sort of arrangement does not hinder the effect intended to be obtained, of an apparently uniform, equal, and homogeneal, compound colour, though it leaves each of these colouring matters without any benefit or support from the other, in regard to its stability or permanency; and it is, therefore, always found, that a fugitive colour is not rendered less fugacious by being employed conjointly with one which is lasting; e.g. a fugitive yellow does not acquire stability by its mixture with an indigo blue; the green resulting from this mixture being found to lose its yellow part in some degree, whilst the blue remains; and this is one of the inconveniences which attend compound colours; for as they are produced from colouring matters, differing very considerably in their ability to resist the impressions of sun, air, &c. they commonly fade unequally, and thus sometimes produce an unsightly appearance.

CHAPTER I.

Of Orange, Green, Purple, and Violet Colours, and their various intermediate Shades or Mixtures.

"Cette partie de la teinture est celle ou les lumieres de l'artiste peuvent etre les plus utiles, pour varier ses procédes, et pour parvenir au but qu'il se propose par la voie la plus simple, la plus courte et la moins dispendieuse."

BERTHOLLET, tom. ii. 302.

ARTICLE I.

Orange, &c.

IN several chapters of this work, particularly those which relate to the application of cochineal, quercitron bark, and madder, I have noticed the ways and means by which the various shades of colour, resulting from the mixture or combination of red and yellow, might be produced upon wool and woollen stuffs. It is, indeed, most easy, by combining the cochineal and quercitron bark in different proportions, with the preparation, or mordants employed in dyeing scarlet, to obtain all the possible shades of colour between the rose and the yellow, with their utmost vivacity and beauty, and with sufficient permanency. Some of these, which are but a few degrees or shades more yellow than the scarlet, may be obtained by employing a portion of either madder, or rubia manjit'h, with cochineal, instead of the quercitron bark; and on the other hand, where nothing higher than the orange is wanted, this may be obtained with great beauty and perfection, merely by an *accumulation* of the quercitron yellow, upon the basis of tin, as mentioned at p. 96, of this volume.

Where shades of orange are wanted, without their utmost vivacity, upon wool and woollen cloths, they may be obtained by combining the colouring matter or either madder or manjit'h, with that of weld, or of quer-

citron bark, upon the aluminous basis. In this last case, after preparing the wool or cloth as usual with alum and tartar, it is commonly thought best to apply the red first, and afterwards the yellow, in a separate bath, at least if the red part of the colour is to be applied in a greater proportion than the yellow.

As neither cochineal nor the tin basis can be advantageously employed to dye linen or cotton, it is expedient for these substances to rely solely upon that of alumine, and to select the red colouring matter from those mentioned in chapters three and four, of the preceding or third part, (especially madder,) combining it with the yellow either of weld, quercitron bark, or morus tinctoria, in such proportion as will suffice for the colour wanted.

ARTICLE II.

Green.

In the chapter relating to the quercitron bark, I have sufficiently noticed its application for producing, with indigo, all the different shades of green* upon wool, silk, linen and cotton; and as the blue from indigo is always a component part of this colour, I can have nothing to add here upon this subject, but what relates to the substitution of other *yellow* colouring matters for that of the quercitron bark, particularly those of weld, and dyers' mulberry, called, improperly, old fustic. The

* The vegetable productions of the earth, are principally adorned or distinguished by this pleasing colour; and so are many of the animal, particularly birds, fish, reptiles, and insects; and though it has not been allotted by nature to mankind, they have long been accustomed to clothe themselves in it. By the followers of Mahomet, it is, indeed, the most venerated of all colours, as yellow is in China; and the more it partakes of this last colour, by so much is it the more lively and gay.

latter of these, as I formerly mentioned, has been commonly preferred for dyeing Saxon greens, because its yellow colour is of all others the least depressed by the acid of the sulphate of indigo; but this motive does not apply to those greens, the blue part of which is first communicated by the *indigo vat*, and the yellow by a subsequent dyeing with weld, quercitron bark, dyers' saw-wort, &c. The latter of these is, indeed, in one respect to be preferred for this use, because its yellow naturally inclines to green. When greens are dyed in this way, (i. e. from the indigo *vat*,) the blue part of the colour is most permanent, and the yellow first decays, but the reverse happens with Saxon greens. Dyers are frequently required to superadd a brown colour to the *green*, as in that which is called *bottle* green, and this may be well done by employing a little logwood and sulphate of iron, with the yellow and blue colouring matters.

In dyeing silk green from the indigo *vat*, it is commonly thought best to apply the yellow *first*, and to prefer that which the saw-wort affords.

To dye beautiful greens upon cotton, Chaptal recommends that it be first dyed of a sky blue colour, from indigo dissolved by potash and orpiment, then macerated in a strong decoction of sumach, then dried, and soaked in the acetate of alumine, dried again, rinced, and finally dyed with *quercitron bark;* employing twelve pounds of the latter to fifty pounds of cotton. He prefers the quercitron bark to weld for this purpose, because the colour of the latter does not combine so well with sumach, as that of the bark. (See Berthollet, tom. ii. p. 316.)

ARTICLE III.

Purple and Violet.

These colours, with all their shades or variations, may be produced *permanently*, and with much vivacity upon wool or woollen stuffs, by combining the rose or crimson of cochineal with the blue of indigo; and they may be obtained with even more vivacity, but less permanency, from either logwood or orchall, as mentioned in the first and third parts of this work.

To dye cloth of a purple or violet colour, a light blue, proportioned to the depth of the colour intended to be compounded with it, is first dyed by the indigo vat, and being alumed by the usual boiling with alum and tartar, it is afterwards dyed with cochineal, employing from half to two-thirds of the quantity required for scarlet, according to the shade of the purple or violet intended to be produced. Lilac and other light colours of this sort, may be produced by employing these means more sparingly, and by taking advantage of the remnants of colour in the baths employed to dye full violets or purples. Pœrner recommends the sulphate of indigo, instead of the indigo vat, as affording a brighter blue, for producing purple and violet colours; but the blue so obtained will have less stability than the other, and be liable to fade, in some degree, before that part of the colour which is derived from cochineal.

In making this use of the sulphate of indigo, Pœrner *begins* by preparing the cloth with alum, then dyes it with cochineal, and more than an equal weight of tartar; and afterwards, adds the sulphate of indigo to the same dyeing liquor, and continues the boiling one quarter of an hour longer.

It can hardly be necessary for me to observe, that in each of these ways the cochineal colour will only be

united to the aluminous, and not to the tin basis; and, consequently, that it can only produce a crimson, of much less vivacity than the rose colour which it would afford with a nitro-muriate of tin. But this last mordant has been always avoided in dyeing the purple and violet colours with indigo, because the nitric acid would unavoidably injure the indigo blue. But since my discovery of the utility and facility of employing the muriosulphate of tin with cochineal, as mentioned at p. 358 of my former volume, this obstacle to the use of a tin basis, for producing purples and violets with indigo, can no longer exist, the muriatic acid having no power to act upon that substance, nor, indeed, the sulphuric, when so much diluted; and my experiments have proved that the colours in question may be dyed by thus substituting the tin for the aluminous basis, with an increase of beauty and vivacity, especially if the blue part of these colours be dyed from a sulphate of indigo instead of the blue vat. Some varieties of purple and violet may be produced by substituting madder for cochineal; but though lasting, they will be less beautiful. Silk, previously dyed blue in the blue vat, being macerated in the murio-sulphate of tin sufficiently diluted, may be made to receive a fine and lasting purple or violet, according to the shade of blue previously communicated, by dyeing it with cochineal. At present, however, these colours are usually produced upon silk, by first giving it a crimson colour from cochineal upon the aluminous basis, and then passing it through a weak indigo vat, the sulphate of indigo being more fugitive upon silk than upon wool.

Orchella, and also Brasil wood, with the indigo blue, are frequently employed to produce purple and violet colours upon silk, but when so produced, though very lively and beautiful, they have but little stability, except

in the indigo part of the colour. Silk impregnated with the aluminous basis, or that from the nitro-muriate, or other solutions, of tin, may be made to receive different shades of purple and violet from logwood, though the colours so produced will not prove lasting.

Cotton macerated in a decoction of galls (employing one pound of the latter to six pounds of the former,) then dried, and afterwards soaked in a saturated solution of equal parts of alum and sulphate of iron, being dried, rinced, and dyed with its weight of madder, will obtain a *fast* colour, which, by varying the proportions of alum and of sulphate of iron, may be made to incline more or less to the purple or violet; and it may be rendered more bright, by boiling it afterwards for a quarter of an hour, in a weak solution of soap. An acetate or pyrolignite of iron, may be substituted with advantage, for the sulphate of that metal.

Violets and purples still *more durable*, may be given to cotton prepared and dyed as for the *Turkey red;* with this difference, however, that to the alum steep, or mordant, a portion greater or lesser of sulphate of iron is to be added, according as the colour is wanted to partake more or less of the dark or violet shades.

Cotton which has received a light indigo blue, may also be made purple or violet, by impregnating it with the aluminous basis, and dyeing it with madder, as formerly directed.

Besides these results of the several binary combinations of the primitive colours, a much greater variety of tints (for many of which there are no proper names in the English language) may be composed, by uniting them *all* in different proportions. Of these Pœrner has given numerous illustrations and explanations, to which I must refer those who desire more information respecting them, especially as it would be impossible for me,

by *English* words, to convey accurate ideas of the effects of most of these mixtures; and, moreover, as the dyer in making them, will derive much more advantage from his practice, than from the theory of this art. Many, indeed, of these variations of colour may be cheaply and expeditiously obtained, by *turning* or *saddening* other colours, already described; for which purpose, several of the earthy and metallic solutions, (and especially the sulphate of iron,) with the different acids, alkalies, &c. are commonly employed, and frequently assisted by logwood, galls, sumach, walnut-rinds, &c. by which an almost endless variety of changes may be produced. Some of these have been already noticed in the former parts of this work, and others are known to practical dyers; to whose experience and judgment I must commit this part of my subject, which would otherwise produce an inconvenient extension of my work.

CHAPTER II.

Of the Black Dye, and of the common Writing Ink, as connected therewith.

"Nothing more is requisite for producing all the variety of colours, and degrees of refrangibility, than that the rays of light be bodies of different sizes; the least of which may make a violet, the weakest and darkest of the colours, and the most easily diverted, by refracting surfaces, from the right course; and the rest, as they are bigger and bigger, may make the stronger and more lucid colours, blue, green, yellow, and red, and be more and more difficultly diverted."

NEWTON, OPTICS. QUERY 29th.

An object, if any such existed upon or above the surface of the earth, which neither reflected nor transmitted a single ray of light, would be absolutely invisible, and incapable of exciting any sensation or perception of colour. That which is denominated *black*, therefore, does not result from a total absorption, or retention, of the several rays, or a complete obstruction of their motions; but from a very scanty and feeble transmission or reflection, principally of those rays which are dark coloured; consequently, the blackest objects are those which absorb or intercept the greatest proportion of these rays, and especially of those whose colours are most lucid; perfect blackness approaching, or being related most nearly to the *total absence of all colour*, and yellow being of all colours the most remote from black.

This absorption or interception of the rays of light, so far as it is necessary to produce blackness, may be effected in dyeing and painting, by a great accumulation and condensation of *all* the primitive or simple colouring matters in union with each other;* and even by

* It was in this way that those once famous dyers, of the name of *Gobelin*, at Paris, were accustomed, for many years, to dye their finest and best *blacks*. They began by giving to their white cloths

such an accumulation and condensation of particles, which, while dispersed, could only produce a single dark colour, particularly the blue or violet, though a *mixture* and condensation of two colours may render the black more *intense*.* This sort of accumulation or condensation, is produced more easily upon wool than upon linen or cotton, and more easily upon the latter than in a *fluid* mixture.†

a deep blue ground from the *woad* vat, and afterwards boiled them in the usual way, with alum and tartar, and then dyed them with madder and weld, which, upon the aluminous basis, produced a red and yellow in addition to the blue; and from this combination of these three primitive colours, a very durable black resulted, which, having been produced without *iron*, must have been exempted from the rottenness which the oxides of that metal have been generally supposed to occasion. From this combination of colours, no more than a very sparing transmission or reflection of coloured rays could result; as the woad ground would only reflect or transmit those of a blue colour, which last the madder red would either absorb or intercept; and the weld yellow would do the same in regard to the red proceeding from the madder; which red, in conjunction with the woad blue, would permit but a very few rays to escape from the weld yellow. Such an obstruction or retention of the rays of light *generally*, must, of necessity, give the effect or appearance of blackness; an effect similar to that which painters produce by mixing their blue, red, and yellow pigments, in suitable proportions.

* A sufficient proof and illustration of this may be seen at p. 173 of my former volume. But the sulphate of indigo, which, as is there stated, produced a very perfect black on woollen cloth, by mere accumulation or condensation, will not, without additional means, produce a similar colour on linen or cotton.

† A proof of this may be seen, by adding any, even the most oxygenated solutions or oxides of iron, to the infusions or decoctions of madder, when it will be found, that such additions will produce nothing darker than a tobacco or coffee brown. But if linen or cotton be sufficiently impregnated with an acetate or oxide of iron, and dyed with madder, a full and permanent black will be the result, and it is in this way that the most durable black of the calico printers is produced.

There are, however, several animals and vegetables possessing colouring matters, which, by mixture with solutions, or other preparations of iron, in certain states of oxidation, immediately produce a black liquid, as is seen in the familiar instance of common writing ink; and as the black dye, in most general use, depends chiefly upon a combination similar to that by which ink is produced, it seems proper that we should more particularly consider this latter production, which happened to engage my attention so early as the year 1770; when opinions demonstrably erroneous respecting it, were promulgated and believed, as they have since been, by the greatest chemists and philosophers of their times.

According to one of these opinions, (then universally admitted, and still subsisting,) the property manifested by galls, and many other vegetables, of producing a black ink, or colour, with sulphate of iron, was ascribed solely to another property, denominated astringency, of which the former was assumed to be, both the *measure, criterion, and proof.** But as this opinion necessarily

* Evidence of the prevalence of this opinion at that, as well as at subsequent periods, may be found in books of the highest authority. Dr. Lewis, in his Philosophical Commerce of Arts, a work of great merit, considering the time at which it was published, when treating of the production of ink by galls and sulphate of iron, adds, that "the power by which vegetables produce this blackness, and their *astringency*, or that by which they contract on animal fibre, and by which they contribute to the tanning of leather, seem to depend *on one and the same* principle, and to be *proportioned* to one another." Dr. Cullen also, in the *first* edition of his Materia Medica, (p. 177, 4to.) states as one characteristic of astringents, that their "decoctions thrown into a solution of green vitriol, strike a black colour and form an ink;" and that those "which give the *blackest ink*, provided they are not accompanied with any peculiar acrimony, which discharges their use as astringents, may be reckoned the strongest and best." The celebrated Macquer also, in his Art de la Teinture en Soie, printed in folio, under the sanction of

produced fallacious conclusions in regard both to the chemical and medical powers, or effects, of a considerable number of vegetables, I thought it my duty to contest it; and this I did, in a communication which was read to the Royal Society, at one of their meetings in the month of May, 1773; in this, among other things, I asserted, that there were a considerable number of vegetable matters, which, though they decidedly manifested *strong astringent powers, were*, as I had found by repeated experiments, *absolutely incapable of producing any degree of blackness*, properly so called, by being mixed with sulphate of iron; and, on the other hand, that there were *other vegetables in which no astringent power was discoverable*, though they *copiously produced a black colour*, when mixed with this sulphate.

I alleged various instances of each of these *sorts* of vegetables in support of my assertion,* and, as I be-

the Royal Academy of Sciences at Paris, says, "En general toute teinture noire est composée pour le fond, des ingredients avec lesquels on fait l'encre a écrire; c'est toujours du fer dissont par des acides, et precipité par des matieres astringentes vegetales." Much more evidence to this effect might be adduced, if the fact intended to be established by it were not so notorious, as to render it unnecessary.

* It will, probably, be thought sufficient for me here to mention the following as instances of these several sorts of vegetables, viz.

Among those which are most decidedly astringent or *acerb*, but incapable of producing blackness with iron, are

1st. The bark of the quercus nigra, Linn. or quercitron bark, lately described: its taste is strongly astringent; it efficaciously coagulates and precipitates glue, and is generally employed in North America to tan skins, which it does speedily and effectually, though its decoction or infusion will not produce any thing more than an olive brown or drab colour with iron, in any state of solution or oxidation; nor is it capable of dyeing a black colour with that basis, by the greatest possible accumulation or condensation even upon wool; as I know by the results of many trials.

2d. The

lieve, sufficiently demonstrated, that, though the so called astringent vegetables, do many of them possess

2d. The bark of the rhizophora mangle, or red mangrove, also lately mentioned, which manifests great astringency to the taste, precipitates glue expeditiously and copiously, and tans skins very speedily and efficaciously, being generally preferred and employed for that purpose by the Spaniards in different parts of America; but, like the quercitron bark, it is utterly incapable of producing a black ink, or dyeing a black colour, with any solution or preparation of iron, even though accumulated and condensed upon wool, by long boiling therewith.—Mahogany bark possesses astringent and other properties exactly similar to those of the mangrove bark, and, like the latter, it is incapable of producing a black with iron.

3d. The extract of the mimosa catechu, formerly called terra japonica, and by Linnæus erroneously supposed to have been obtained from that species of palm which produces the areca nuts, and which he, therefore, denominated areca catechu. There are two varieties of it, one imported chiefly from Bombay, and the other from Bengal; but, though differing in external appearance, they manifest the same properties. Both of them are highly astringent, though a little sweetish to the taste; and both have been found by Sir H. Davy and Mr. Purkis, of Brentford, to tan skins most powerfully; but neither is capable of producing a black ink, or dyeing a black colour, with any, even the *most oxygenated* preparation of iron. This I assert, from the results of experiments repeated many times, not only with parcels of this drug as sold in the shops, but with some choice specimens which I received from Dr. Roxburgh, the late Mr. Tiberius Cavallo, and others; of which no one, in a single instance, was found to produce any thing darker than a *snuff* colour, with the most oxidated sulphate of iron, even that to which nitric acid had been purposely added, to increase (as it does with galls) the blackness resulting from its application. I have *asserted* these facts more *distinctly*, and in *stronger terms* than I should have thought necessary, had not Sir H. Davy, in the very lucid and judicious account which he gave to the Royal Society, of his experiments and observations on the constituent parts of astringent vegetables (published in the Philosophical Transactions for the year 1803), after admitting that "the *least* oxygenated sulphate of iron produced no change in the infusion" of catechu, stated (at p. 255) that "with the *most* oxygenated sulphate, it gave a *dense black* pre-

matters capable of producing blackness with iron, (in a suitable state of oxidation,) they do not possess it exclu-

cipitate, which, when diffused upon paper, appeared *rather more* inclined to olive than the precipitate from galls:" and had he not also stated (at p. 258) that "an aqueous solution of the pure extractive matter of catechu being added to the solution of oxygenated sulphate of iron, it communicated a fine grass green tint; and that a green precipitate was deposited which became *black* by exposure to the air." Before these statements fell under my observation, I had made, probably, fifty experiments with mixtures of *catechu* and iron in different states of oxygenation, which were begun in the hope that the former, from its moderate price, might be found capable of being advantageously employed upon a large scale, in producing a *prosubstantive black* for calico printers; but I had completely laid it aside, with the fullest conviction, that it could not be made to produce any thing *like*, or even *approaching to a black* colour, by or with any preparation of iron whatever. In consequence, however, of these statements by Sir H. Davy, I was induced to renew my experiments, and with a greater variety of specimens of the catechu; but from none of them could I produce, by any degree of oxidation given to the iron, or any subsequent exposure of the mixture to the air, any thing darker, when diffused on paper, than the snuff colour already mentioned, which, to my apprehension, is very far removed from black. Whether the catechu employed by him was adulterated, or whether, from believing that according to the general opinion, this substance as an astringent *must produce blackness with iron*, he was led to employ expressions *exceeding the effect* really produced, I know not; but there seems to have been a want of Sir H. Davy's *usual accuracy* in these statements, particularly when he describes the *dense black* precipitate from catechu as appearing, by diffusion upon paper, "*rather more inclined to olive than the precipitate from galls.*"—Probably no person ever made more precipitates than I have done from mixtures of iron and infusions of galls; and I do not recollect that any one of them *ever inclined to olive*, though, by varying their proportions, a variety of shades or tints may be produced between a reddish brown black, and a bluish or violet black—the former occurring when the galls are in excess, and the latter, with an excess of iron or its oxide. But how *an olive* could result from any such mixtures I know not.

Of

sively, but in common with other vegetables which are destitute of astringency; and that this last property, therefore, is not necessarily or constantly connected with, or denoted by that of producing a black colour with iron, or any of its preparations.

Of the vegetables which *manifest no astringency*, though they abound in colouring matter, which produces a black ink, and black precipitates with iron, the following instances may suffice, viz.

1st. The bark of juglans oblonga alba, white walnut or butter nut of North America, of which the decoction very decidedly and copiously affords a black ink with sulphate of iron, and strongly communicates that colour, by dyeing, to wool, silk, linen, and cotton, though it discovers no astringency to the taste, nor causes any precipitation with gelatine.

2d. Logwood, or its decoction, which is sweetish, but not in any degree acerb to the taste, nor capable of producing the slightest precipitation with glue, (until by long keeping, it has acquired new properties, as stated at p. 255 of this volume,) and yet its abundant power of producing a black ink, and of dyeing that colour with iron, has long been notorious. The fact, indeed, of its possessing this power has induced physicians to suppose, that it *must* be an astringent, and to employ it as such medicinally—which is one proof of the errors resulting from the groundless opinion here controverted.

3d. Brasil wood, and the several other species cæsalpinia, lately mentioned, the decoctions of which are completely destitute of any thing like an astringent, austere, or rough taste, and of even the slightest power of occasioning a precipitation with gelatine; and yet, like logwood, they copiously afford a very black ink with iron, and dye that colour with sulphate of that metal.

Other and similar instances might be found in madder, galium, &c. which notoriously afford most permanent blacks, even upon linen and cotton, with iron, though they are completely destitute of astringency and of the tanning principle. The like instances may also be found in the animal kingdom, particularly in the cochineal insect, which, with sulphate of iron, produces a deep black ink, and a black dye, though it has never been found to possess the least astringency.

At that period, the rottenness which was generally complained of as attending black cloths, had been ascribed to the *acid* part of the sulphate of iron, employed to dye that colour,* and this acid, being also supposed to accelerate the decay of writing ink, I was induced to endeavour to effect a direct combination of iron with the soluble part of galls, without the intervention of any acid; and for this purpose, having made a decoction of galls, I put to it a quantity of clean iron filings, and, in a little time, perceived that this mixture occasioned the production of a considerable number of air bubbles, and an escape both of inflammable air and carbonic acid gas, together with a brownish discoloration upon its surface; which discoloration continued to increase, as well as the extrication of hydrogen and carbonic acid gases, for the space of twenty-four hours; when the mixture had acquired a decidedly full black colour on its surface, though internally it appeared, upon examination, to be only of a brownish purple; but, being applied to paper by a pen, it soon became black, by an absorption of oxygene. This was in the summer season, and the decoction of galls having been left to act upon the iron filings twenty-four hours longer, I judged from its appearance, that a sufficient solution and combination of iron had taken place, and, therefore,

* That I may not multiply proofs of this well-known fact unnecessarily, I shall content myself with the following extract from M. Macquer's Art de la Teinture en Soie, viz.

"Ce qu'il y a deplus essentiel a observer sur la teinture noire, c'est qu'on général, elle altere et ènerve beaucoup les ètoffes; ensorte que celles qui sont teintes en noir, sont toujours beaucoup plutôt usées, toutes choses égales d'aillieurs, que celles que sont teintes en d'autres couleurs: C'est principalment a *l'acide vitriolique* de la caperosè, lequel n'est que imparfaitment saturè par le Fer, qu'on doit attribuer cet inconvénient." Other and similar proofs will occur speedily.

separated the fluid part, by a strainer, from the iron filings; and by exposing the former in an open vessel, I found the next day, that it was become deeply black, and that (being applied to paper with a pen) it was capable of answering the purpose of ink extremely well. Having repeated this experiment several times with the same result, I employed this direct combination of the colouring matter of galls with iron, as a *dye* to wool, silk, and cotton, and found it to produce a good black upon each of these substances; and I, therefore, thought myself warranted to conclude, in opposition to what had been alleged, particularly by the late Dr. Percival, (in his Essays Medical and Experimental, and especially from his Experiments 37—39,) that the sulphuric acid was not *an essential* constituent part of ink, or of the black dye, but that both might be produced, and, as I thought, with advantage, by directly combining the soluble part of galls with iron. And these conclusions, together with the experiments from which they had been drawn, were likewise stated in the communication which I made to the Royal Society, as lately mentioned; but as I then announced my expectation of speedily *adding* to it a farther account of the benefits to be derived from the application of this *discovery*,* to the purposes of dye-

* Dr. Lewis, though he had completely adopted the opinion which I recently mentioned, of the real or supposed injurious effects of sulphuric acid, as a constitutional part of ink, and of the black dye, and though he made trials of iron dissolved by other acids, instead of the sulphate of that metal, without any benefit, as he conceived, yet he did not attempt to effect a combination of iron directly with a decoction of galls. Such an attempt was, however, made afterwards by the late Dr. Percival, but as he employed a *cold* infusion of galls, and, probably, in *cold weather*, without allowing sufficient time to obtain the desired effect, his experiment failed, and he concluded this *direct* combination must be impracticable. It was, however, effected by M. de Monnet, and his asso-

ing, the Committee of Papers thought proper to wait for that *addition*, before they decided upon the publication of my first communication; and having waited in vain, until the 3d of March, 1774, the late Mr. Walsh, then a member of the council, on that day wrote me a letter (which is now before me) requesting in their behalf, to know my "intentions about giving an additional paper to the society on the subject of colours, the Committee of Papers having deferred the consideration of that of the last year in the expectation of such a paper." In answer to this letter, I informed Mr. Walsh that it was still my intention soon to finish, and send to the society the additional paper in question, and also intimating, that as the Committee had waited so long for it, my desire was that they should continue to do so. After this, circumstances occurred, of which a detail would now be useless, to hinder me from fulfilling the intention so declared; and this additional communication having never been made, no notice was, of course, taken of the *first*, in the Philosophical Transactions; and, consequently, the errors which it was intended to correct were left to subsist, as some of them do, at this time.

The ink, formed by this direct mixture of iron-filings with the soluble parts of galls, when they were combined in suitable proportions, was found, if employed within a few weeks after being made, to produce upon the paper a very smooth, full, and lasting black; but when long kept, it did not fulfil my expectations, as it seemed even more disposed than common ink to become mouldy, and also to concrete and subside in the

ciates of the Academy at Dijon, about the year 1778, *five years* subsequently to my communication to the Royal Society on this subject; of which, however, it may be presumed, that these academicians were ignorant.

form of a black powder; defects which, in common ink, probably are, in some degree, obviated by the influence of sulphuric acid; for though this acid may, as is supposed, accelerate the decay of ink after its application to paper or parchment, as in old writings it probably retards the commencement and progress of mouldiness, whilst the ink is in a *liquid* state, and enables the water for a longer time to hold in a state of solution or suspension, the black compound of oxidated iron and the colouring matter of galls, which, if their affinities are not counteracted by sulphuric, or some other acid, will unite more *closely* and exclusively, and by detaching themselves from their aqueous solvent, will subside like *charcoal* finely powdered; an inconvenience, indeed, to which common ink is, in some degree, liable, and more especially when it is either much diluted, or not sufficiently gummed.

When the decoction of galls, and the iron filings, were mixed and left together, until an *excessive proportion of the latter* had been dissolved and combined with the former, the black compound appeared still more disposed to concrete exclusively, and subside in large particles; and if, by shaking, these were again diffused through the water whence they had subsided, and applied by a pen to the surface of paper or parchment, they did not, in the smallest degree, penetrate the substance of it, like common ink, but, when dry, might be rubbed off, as if powdered charcoal only had been applied. They were, indeed, easily made soluble in water, by adding to it a sufficient portion of sulphuric acid; but this only produced a mixture similar to the common ink, when made with an excess of the sulphate of iron. And, after many trials, I found that the best expedient for rendering ink useful, when produced by a direct mixture of iron-filings with a decoction of galls, was

that of combining the latter with only so much of the iron as was barely sufficient to produce a black colour, when the mixture had become sufficiently oxygenated. By this sparing use of the iron, and the addition of a suitable proportion of gum, the deposition of black matter was, in a great degree, obviated, and the ink, from specimens which I have preserved of it, has appeared to be very lasting, at least if employed before it had suffered by long keeping in a moist state, in which it was still liable to become mouldy, perhaps more speedily than ink made with the sulphate of iron. Delaval has, however, greatly commended ink formed by this direct mixture of iron-filings and the decoction of galls, (though without acknowledging the inventor); and Proust, as Berthollet observes, (tom. i. p. 126,) has given a decided preference to such ink.

Some years after my communication to the Royal Society, Scheele, by exposing a cold infusion of galls to the open air during a whole summer, obtained from the residuum, which had become almost dry, (by dissolving it with hot water, filtering, and again evaporating,) a crystallized salt, which, when added to a solution of the sulphate of iron, made it black like a decoction of galls. This salt, which has since been denominated *gallic acid*, Scheele supposed to *exist ready formed* in the galls, but to be so intimately combined with some mucilaginous or other matter, as to be incapable of crystallization, by the ordinary means, or without some internal movement or change, like that which occurs during fermentation: and this supposition has been since generally adopted by chemists, who have attached great importance to Scheele's discovery of the so called gallic acid, and attributed to it all those properties, which have been thought to characterize and distinguish that class of vegetables, commonly called astringents; though

they have, as I think, done it most unwarrantably, because Berthollet and others have all failed in their numerous attempts to obtain this acid from even a single one of this class of vegetables;* and not being found or contained in them, we cannot be justified in taking *it* as the exemplar and evidence of their properties. There is, indeed, so far as I can judge, good reason to believe, that this gallic acid has no natural existence any where, and that it is a production of art, or, perhaps, more strictly a modification of the acetic, or other acid, to which astringents are principally indebted for their *acerbity*. That an important modification of this acid should take place, during the *long* continuance of Scheele's process, might well be expected, especially as he has himself stated considerable changes to have occurred in regard to the infusion of galls from which it was obtained, and which had not only become very mouldy, but was covered by a mucous pellicle, and had *lost all its styptic taste*, a considerable time before the operation terminated.

When, in addition to Scheele's discovery, Seguin had taught us how to recognize or ascertain the tanning principle in vegetables, by mixing glue with their infusions, or decoctions, attempts were made to separate the latter from the gallic acid, and obtain each in a distinct and pure form.

* See his Elements, &c. tom. i. p. 108, &c. Davy (see Philosoph. Transactions for 1803, p. 268) was disappointed in his expectation and endeavour to obtain gallic acid from the fruit of the *terminalia* chebula, or yellow myrobalans, which, by my experiments, have appeared to afford, when the nut was removed, nearly as much of that colouring matter which produces a black with iron, as the best Aleppo galls, and to produce this colour as efficaciously, perfectly, and permanently, even upon linen and cotton, with the several preparations of iron.

Among the means employed to effect this separation, those recommended by Proust, and which depend chiefly upon the muriate, or nitro-muriate of tin, (see Ann. de Chimie, tom. 25 and 41,) seem to be most efficacious, though they are admitted to be insufficient; the gallic acid, after such separation, always retaining a little of the tanning principle, and the latter a little of the acid.

I have given some account, in the preceding chapter, of the origin and constituent parts of galls, to which I must refer my readers. From the *cause* and manner of their production, we might naturally expect that they would only consist of matters, afforded by the juices of the oak on which they grow; which juices, in consequence of the stimulus given by the larva of the gall-fly to the adjacent vegetable fibres, circulate and accumulate more copiously than they would otherwise do, around the offending insect, by a sort of *inflammatory process*, like that which is produced by a thorn in human flesh; and, therefore, though these vegetable excresences might contain some matters derived from the oak, in a more *distinct* and *pure* state than that in which they are naturally produced by the tree itself, they could contain *no* matter which the tree had not produced, unless it were afforded by the *insect*. But the latter is not known, so far as I can discover, to possess any matter capable of producing a black with iron, and even if it did, we might reasonably conclude, that it must have been imbibed or derived from the juices of the oak, which notoriously contain it; and, therefore, though galls confessedly contain both tanning and tingent matters, in a more *concentrated* and *pure* state than that in which the oak affords them naturally, it may be presumed, that in *every other respect* they are the *same identical matters;* even though it should be true, as M. Chaptal supposes, that galls possess something of an

animal nature, (which, indeed, they must do, if employed before the insect has escaped from them.) For unless it were proved, that the insect possessed, and could impart to the galls some tingent matter *peculiar to itself*, and similar to the supposed gallic acid, there is no reason to suppose that the *animal* nature of the gall-fly, or its larva, would materially change the properties of either the tanning or colouring matters *naturally* produced by the oak; and we are warranted in believing, that in fact no such change is produced by this insect, because M. Berthollet states that, by his experiments, the *white* galls (from which the larvæ must have escaped) appeared to yield more of the gallic acid than the *blue* galls, which always retain the insect. (See Elements, &c. tom. i. p. 108, &c.) And as he also states, that he had not been able to detect any gallic acid in oak bark, we have an additional reason for believing, that this acid is not a natural production; more especially as, since different ways of procuring it have been made known,* its properties, as Bouillion La Grange has remarked, are found to differ according to the method in which it has been obtained. (See Ann. de Chimie, tom. lx. p. 156.) Many new names and distinctions among the acids have, indeed, been introduced within the last forty years, founded only upon *trivial* modifications, *produced by art;* and if my memory does not mislead me, Scheele also obtained the supposed acid of sugar, as well as gallic acid, from galls.

It will have been observed, that in the preceding parts of this work, I have invariably applied the name

* One of these additional ways, not yet mentioned, is that discovered by Deyeux, of distilling the precipitate of an infusion of galls, made with carbonate of potash, by which a *very small* proportion of this acid may be obtained.

of *colouring* matter to those parts of vegetable dyeing drugs which are found to produce colour with an earthy or a metallic basis; and I have, certainly, never been able to discover any good reason for doing otherwise, in regard to those vegetable matters which afford ink, or a black dye, with iron; matters which, indeed, are extremely various in their *other* properties, and *even in the sorts of black* which they produce; though chemists have, as I think improperly, confounded most of them, under the general denomination of *astringents;* a term which may be unobjectionable, as signifying *acerbity* in vegetables, but not as indicating, or being invariably connected with, any such property or matter as they have been supposed universally to possess, that of producing a black colour with iron.

The tanning *principle*, if it deserves to be called a *principle*, notwithstanding its varieties, is found much more constantly in the acerb or astringent vegetables, than the colouring matters producing black with iron; and this last is very frequently united with tannin, but not invariably, as we have lately seen by the facts stated in regard to the catechu, and others matters employed for tanning.

M. Berthollet has appropriated an entire chapter to the subject of *astringents*, (des astringents,) which name, says he, designates a property *common* to a great number of vegetables, (" une proprieté commune a un grand nombre de vegetaux"): he confesses, indeed, that there is no other property in them, concerning which people have been satisfied with such vague ideas; nevertheless, continues he, *every substance which renders a solution of iron black*, has been commonly deemed astringent, or acerb;* and this effect has been attributed to *one*

* Sir H. Davy (probably from what he saw in his experiments with *catechu*) seems to have endeavoured to *amend* the common

identical principle, residing in the substances producing this effect;* experience, however, says he, has since shown that it is necessary to admit *two sorts of astringents*, viz. tannin and the gallic acid: and he adds, that both of these precipitate iron, and produce with it a bluish black colour, (tom. i. p. 105): but this, though true of the tannin afforded by most of the oaks, is not true of that contained in the quercitron *oak*, or in the mangrove, &c., nor of that which chiefly constitutes the *catechu*, as I have already noticed, so that we find, even in this, the most recent and correct elementary work on this subject, a *renewed assertion* of the errors, which I long since controverted, and which I am now endeavouring to overcome, by facts, which, when properly

definition, or notion of the properties of an *astringent*, or rather of the *gallic* acid. "The presence of tannin," says he, "in an infusion, is denoted by the precipitate it forms with the solution of glue or of isinglass: and when this principle is wholly separated, if the remaining liquor gives *a dark* colour, with the oxygenated salts of iron, and an immediate precipitate with the solutions of alum and of muriate of tin, it is believed to contain *gallic acid* and extractive matter." Phil. Trans. for 1803, p. 234. By this substitution of a *dark*, for a *black* colour, as a criterion of the presence of *gallic* acid in an infusion, to which an oxygenated salt of iron has been added, a foundation is laid for very erroneous conclusions; there being, so far as my recollection extends, no *adjective* colouring matter, either animal or vegetable, which is not *darkened*, at least, by the oxygenated salts of iron; and if the latter do not darken some of the *substantive* colouring matters, as that of indigo, and that of the buccinum lapillus, it is only because these matters form no combination with the oxide of iron.

* "Cependant on a regardé ordinairement comme astringent, ou comme acerbe, toute substance qui change en noir une dissolution de fer; on a supposé que cet effet étoit dû à une principe identique, qui réside dans toutes les substances qui le produisent. L'experience à fait voir ensuite qu'il falloit admettre deux espèces d'astringent, savoir, le tannin, et l'acide gallique." Elements, &c. tom. i. p. 95, 96.

made known, cannot fail of producing more accurate opinions respecting these matters.

M. Berthollet, after having thus arranged the tanning principle, and the gallic acid, as *two sorts* of astringents, proceeds (tom. ii. p. 113, &c.) to notice and compare their respective properties; and in doing this, he represents the affinities of tannin, as differing but very little from those of the gallic acid, at least in those combinations which relate to dyeing; but he remarks, that the compounds of the latter, generally manifest more stability, than those of the gallic acid; that it forms an insoluble substance with gelatine, whilst the gallic acid combines, and remains with the latter in a fluid state; and that it unites with the solutions of iron, forming a precipitate, which speedily separates and subsides; whilst the gallic acid merely produces, with these solutions, a transparent (black) liquor, from which the coloured particles only subside, *after a great length of time*, and by the aid of particular circumstances: but the most important difference between these matters, presented itself in applying them to silk, linen, and cotton; which, after being impregnated with the gallic acid, could not be made to take a black colour, by being dyed with any solution of iron; though these substances, when treated in the same manner with tannin, obtained good blacks. Similar results happened when the iron basis was *first* applied to the silk, &c. and the tannin and gallic acid *afterwards*, and from these experiments he infers, that though the gallic acid may *co-operate* with tannin, in producing a black by dyeing, it must be useless for that purpose when employed *alone* (with iron). He admits, however, that the tanning principle acts efficaciously in this way *without* the gallic acid.

After this account of the most generally received opinions, respecting the gallic acid and the tanning

principle, I will venture here to state my own conceptions of these matters. I have lately intimated my inability to discover any good reason for not considering the tingent part of galls, oak bark, and other vegetables, producing a black with iron, *merely as a colouring matter*, at least in regard to this effect, as I have done in regard to the substances which afford other colours; and, indeed, it has long appeared extraordinary to me, that this property in *oak galls* should have almost exclusively engaged the attention of chemists and philosophers, whilst other vegetables, particularly the bark of the acer rubrum, and the fruit as well as *galls* of the terminalia chebula, produce a *similar* effect, with equal efficacy, and perfection. These vegetables, like the oak and its galls, give proofs of a considerable portion of *acidity*, (on which their acerbity chiefly depends,) and also of that which is called the tanning principle; and both of these are so intimately combined, with what I shall continue to denominate the colouring matter, that no means have yet been discovered by which either of the former can be obtained separately and distinctly from the latter; and, therefore, it has been found invariably, that the so called gallic acid, and the tannin procured from galls, were either of them always capable of producing a black ink with solutions of iron. But chemists, prepossessed by certain notions about acidity, have strangely overlooked this colouring matter, and ascribed its effects to the supposed gallic acid, as they have done in regard to the colouring matter of Prussian blue, calling it *Prussic acid*, with even greater impropriety, because the latter does not manifest the smallest acidity, whilst vegetables remarkable for their acerbity, do unequivocally give proofs of it; but so far as I can discover, this, their acidity, though co-existent and

united with their colouring matter, is distinct from it, and *useless* in regard to its tingent effects.

In Scheele's process for procuring the supposed gallic acid, the tanning and colouring matters seem to suffer a partial decomposition, though some of both, and especially of the latter, (and, perhaps, the finer and purer parts of it,) remain dissolved by, and united with, the acid producing the acerbity of the galls, which acid preserves them from the decomposition or destruction that occurs to the other parts; and in this way the colouring matter, so united and preserved, is combined with a much greater proportion of vegetable acid, than it is in its original and natural state; and this increased proportion of acid renders it, when mixed with the sulphate of iron in the form of an ink, less disposed to separate and subside, than it is in common ink; for the same reason as that which I lately mentioned, to explain why common ink, made with a solution of iron by sulphuric acid, was more exempt from this defect, than ink produced by a direct mixture of iron-filings with a decoction of galls.

I have here supposed *three* principal constituent matters in galls, and the other vegetables under consideration, though it is very possible that the matter producing colour, and that possessing the property of tanning skins, may be *one* and the same, instead of being *two*, inseparably combined.

On this point it must be extremely difficult, if not impossible, to acquire certainty. But if *one identical matter* produces these several effects of tanning, and affording colours, this matter must be susceptible of various modifications, and actually possessed of properties, which differ even in the quercitron oak, the red mangrove, the mahogany, the mimosa catechu, &c. and which are *very* dissimilar in their tingent effects, at

least from those of the tanning and colouring *matter*, as it exists in the common, as well as most other oaks, and in the acer rubrum, the terminalia chebula, and many other vegetables.

M. Berthollet supposes, that the several vegetables which produce the black colour with iron, must *all* have *one* common mode of acting upon that metal; and after noticing the fact, stated by M. Monnet and his associates, (the Dijon Academicians,) that, by adding a decoction of galls to solutions of gold and silver, these metals were not only precipitated, but *revived* by it, he assumes this *common mode of action*, to be that of producing an abstraction or separation of oxygene from the metallic oxides, and especially that of iron, and thereby occasioning such a partial reduction of the latter metal, as will bring it to the state of a *black oxide*, or Æthiops;* and he also assumes, that these vegetable astringent, or colouring matters, by combining with the oxygene so abstracted, undergo a sort of *combustion*, slight, indeed, but sufficient to render the *carbon* of the vegetable astringent, or colouring matter, *predominant* ("de maniere que *le charbon devient predominant*." See tom. i. p. 122). And by this supposed reduction of iron, to its naturally blackish colour, and the conversion of the vegetable matter to a sort of charcoal, he supposes himself to have given a satisfactory explanation of the production of blackness in common ink, &c.

In regard to the carbonization of the vegetable part of ink, &c. I shall state my opinion presently; and in regard to the reduction of its ferruginous part to the state of a black oxide, I must here mention the fact

* This notion seems to have originated with M. Fourcroy, who (as M. Berthollet observes) had, in 1785, supposed the gallic acid to colour iron black, by restoring it *almost to its metallic state*.

which has been strongly insisted upon by Proust, and observed by all who have attended to the subject, I mean that of the superior efficiency of the *most oxygenated* oxides of iron in producing the *blackest ink;* and the *total inefficiency* of that metal, to produce a black colour with galls when it is but little oxidated, as in the *green* sulphate of iron; at least until the want of oxygene is supplied by an absorption of it, from the atmosphere. This fact is, indeed, admitted by M. Berthollet, but in opposition to it, he alleges, (tom. i. p. 105, 6,) that this unfitness of the *green* sulphate of iron, or of a muriate (but little oxidated) of that metal, to produce blackness with galls, depends solely upon the *too strong action* which these acids exert, upon the iron thus sparingly oxygenated;* which action, as he supposes

* The following facts seem incompatible with this explanation, viz.

Having dissolved iron by pure muriatic acid, with an apparatus which, whilst it permitted the escape of hydrogene gas, precluded the access of oxygene from the atmosphere, I obtained a *white* muriate, or *oxide* of iron, which I mixed with a decoction of galls recently made, and found, as I expected, that the iron in this state did not, in the slightest degree, change the colour which the decoction of galls had previously exhibited. Without loss of time, I immersed three bits of calico in this mixture, and when they had imbibed as much of it as they were capable of doing, I held one of them, which (like the others) was of a pale nankin colour, over the fumes of nitric acid, by which it was sensibly blackened in a single minute. Another piece I dipt in aqua-fortis, and found it to be instantaneously blackened thereby. The third bit was spread out, and left to dry in the open air, by which, after twenty-four hours, the *edges only* were become black by an absorption of oxygene.

As in this experiment an instantaneous blackness was produced by dipping one of the before-mentioned bits of calico into nitric acid, and a very speedy blackness by the application of its fumes to another, no one can pretend that the previous pale nankin colour, or the non-appearance of a black, was occasioned by an *excess of*

in another place, (Essais de Statique, Chim. tom. ii.) disables the vegetable colouring matter, (or gallic acid, as he terms it,) from attracting or taking from these acids, enough of the iron to produce the black colour; and he supposes that a confirmation of this explanation may be derived, from the effects are produced by the *direct mixture* of iron-filings with a decoction of galls, by which a black colour is produced, though the iron, by this mixture, can, as he says, be only brought to the *lowest degree* of oxygenation, ("le fer ne peut etre amené qu'au degré le plus bas d'oxidation." See Elements, &c. tom. i. p. 105.) That the iron is but *little oxidized*, for some time after being put in contact with the decoction of galls, I readily admit; but so long as it continues to be but sparingly oxidated, so long the mixture will only exhibit a *reddish brown colour;* but this will gradually become darker, in proportion to the acquisition of oxygene, by absorption from the atmosphere, and probably also, by some decomposition of the water, affording the hydrogene gas, which continually escapes:* a principal part, however, of the oxygene pro-

acid; since with an addition, and a very great one, of acid, the *blackness was suddenly produced;* and this production can, I think, be ascribed to nothing but the oxygene which nitric acid relinquishes more readily than the sulphuric, which acid did not produce a similar change of colour.

* The acid which predominates in galls and other astringent vegetables, appears to act upon iron like the sulphuric and muriatic acids, though more slowly; and like them, to favour a decomposition of water, which M. Berthollet supposes to happen when iron is dissolved by a direct mixture with the decoction of galls; and this supposition enables us to acoount most readily for the production of hydrogene gas, which is extricated in consequence of such mixture. The affinity, however, between iron and the colouring matter of galls, seems also to co-operate in dissolving the metal. For having boiled powdered galls in water with a portion of

ducing this change, must be derived from the atmosphere, because the colour of the mixture is always many degrees darker at the surface, than it is a few lines below it, and least dark at the botton. It will, indeed, after some time, if not stirred, appear, in a transparent glass cup, to be *quite black* at the top, and to recede in other parts gradually from this colour, in proportion to their distance from the surface. By frequently stirring the mixture, and allowing time for the decoction or infusion of galls to acquire a sufficient portion both of iron and of oxygene, a very full and perfect black will be produced; but we have no reason, so far as I can judge, to believe, that the *component parts* of this colour are not *then* as much oxygenated as those of a similar colour, produced by adding iron, at the *maximum of oxidation*, to a decoction of galls. That iron highly oxygenated, is necessary to produce a full black colour *immediately*, or without waiting for an absorption of oxygene from the atmosphere, is *now* well known: though it seems difficult to understand why it should be so, upon M. Berthollet's supposition, that the iron which contributes to that colour, is only in the state of a *black* oxide. For though galls, and other similar colouring matters, be admitted to have a power of abstracting oxygene from iron, it cannot be necessary that *an excess* of oxygene should be combined with

carbonate of potash, which was more than sufficient to neutralize their acid part, and having added iron filings to this decoction, I found, that though there was but very little appearance of a solution or combination of the metal with the colouring matter of the galls, during the first twenty-four hours, a solution did ultimately take place, so far as that, at the end of six days, in the summer season, an ink sufficiently black was produced, which also gave a black colour to cotton dyed with it.

that metal, *merely that the galls, &c. should have an opportunity of exerting this power, by taking it away.*

It is, indeed, true upon M. Berthollet's assumption, that this superfluous portion of oxygene may be requisite to produce the *combustion* which galls are supposed to undergo, in order that their carbon may be rendered *predominant;* and this consideration makes it expedient that I should here propose some observations in addition to the facts stated between pages 41 and 46 of my first volume, and in opposition to the supposed carbonization of colouring matters by such means; especially as M. Chaptal has adopted the same theory, in his Chim. appliquée aux arts, (tom. iv. p. 282 and 283,) where, after stating that the decoctions of astringent vegetables bring iron into the state of an Æthiops, he adds, that by the action of oxygene upon these decoctions, their carbon is made *visible* or *naked*, ("le carbone *est mis a nu.*") And he adds, that in order to understand this last phenomenon, it should be known, that *next after indigo*, gall nuts are, of all vegetable substances, that which furnishes the *greatest proportion of carbon;* so that, when oxygene is applied to a decoction of these nuts, it forms water with their hydrogene, and their carbon is set *almost free.* ("Le carbone devient presque libre.") Against the existence of carbon as such *naturally*, and with a *black colour*, in vegetable matters of any sort, and, consequently, against the supposition of its being in this way made *naked* or set free, I have alleged facts and arguments (at p. 49 et seq. of my former volume,) more than sufficient, as I believe, to refute this part of M. Berthollet's theory; and I cannot help thinking, notwithstanding my great deference for every thing sanctioned by such high authority, that M. Chaptal's allusion to indigo, as an elucidation of this supposed phenomenon, was at least inconsiderate: for if

the colour of indigo depended upon any thing like carbon, or its basis, that combination with oxygene which is indispensably necessary to render it *blue*, would, upon M. Berthollet's assumption, make it *black* like charcoal; and the putting indigo into *four times its weight* of the most concentrated oil of vitriol, or sulphuric acid, (as is commonly practised for the Saxon blue,) would not, as it is known to do, render its blue colour much more lively and bright, but would, on the contrary, convert the whole to a black coal; as this acid invariably does with vegetable matters containing the basis of carbon or lignin. Not, however, by its oxygene, so much as by the sulphur with which that oxygene is combined; for the nitric acid, which gives up its oxygene more easily, and in greater *purity* than the sulphuric, does not blacken any vegetable matter, so far, at least, as my observations have extended; but, on the contrary, renders them all white; and this fact alone seems decisive in its operation against the theory in question; for if it were true, the sulphate of iron ought to be preferable to the *nitrate*, though the latter, as I have often experienced, is by much the most efficacious in producing a very deep black ink, with a decoction of galls; and the oxygene which this nitrate could alone impart, to the supposed carbonaceous part of the galls, being more suited to *bleach* than to *blacken* this, and every other part of them, no such effect, as that of rendering them black by making their supposed charcoal naked, or predominant, could be produced by any separation of the supposed excess of oxygene from a nitrate of iron.

Were it true, as M. Berthollet imagines, that the black colour of ink results exclusively from the two operations under consideration, viz. the reduction of iron to the state of a black oxide, and a partial combustion of the astringent vegetable matter which combines

with it, a decoction of catechu, or of any one of several other vegetables, (which have been always found incapable of producing blackness with iron,) ought to be able to do it as efficaciously as the decoction of galls; since they are equally efficient in *abstracting oxygene* from the oxides of iron, (so as to bring it into the state of an Æthiops,) and there is no reason to suppose that they are not equally susceptible of the sort of combustion which M. Berthollet imagines to be a consequence of that abstraction.

It is well known that we can deprive ink of its colour, by making it receive a stream of sulphuretted hydrogene gas, which must produce this effect only by causing an abstraction of the oxygene, to which the ink owed its blackness. And if this colourless ink be afterwards applied to paper, it will regain its oxygene, and its lost colour: and these facts seem to me incompatible with M. Berthollet's theory—sulphuretted hydrogene gas having never been found capable of *whitening* charcoal; and if the iron of ink be already, as he supposes, in the *least oxidated* state, it cannot be made *white* by a farther abstraction of oxygene.

The theory which I am here forced to controvert, supposes causes which seem to me very insufficient, and it overlooks or disregards that which, to my apprehension, is the *true cause* of the effect under consideration. I mean the *peculiar nature* and *properties* of *the vegetable colouring matter* (of galls, &c.) which *specifically, though unaccountably*, produces the black colour of ink, with iron, and produces it more *intensely* at least with a *red*, than with the *black* oxide of that metal; if, indeed, it be possible to produce it with the latter. Why it does this, we may be able to explain, when, if ever, we shall discover the cause of those *peculiar affinities* of the several rays of light, by which they are severally

made liable to be variously absorbed, transmitted, or reflected. But until such a discovery shall be made, it cannot be reasonably expected, that any person should execute a task, like that which has been unnecessarily assumed by M. Berthollet; it being no more incumbent on him to account for the production of a *black* colour, by the combination of iron with a decoction of galls, than for the production of a *blue*, by a combination of the same metal, with what is called Prussic acid; or to explain why the *colourless* basis of indigo, when united with a *full* portion of *colourless* oxygene, will copiously reflect, or transmit *blue* rays only; though with a smaller portion, it will reflect or transmit yellow as well as blue, so as to appear green; and with a portion still smaller, it will transmit the yellow, but no blue rays. The colour of logwood, extracted by pure water, is yellow; but it may be made to exhibit almost all possible variations of colour, by combining it with different bases or mordants; though it is, I believe, impossible to explain why any of these combinations should produce one colour in preference to another, especially as it is demonstrably the same *identical* colouring matter, which cooperates in producing all the affinities or attractions for the several rays of light which create these *varied* sensations of colour. Here, therefore, we may say with Pliny, (Lib. xxxvii. cap. 4,) "*Nec querenda* in ista parte *naturæ ratio sed voluntas.*"

After these preliminary observations respecting the philosophy or theory of the black colour, as produced by the means under consideration, I shall proceed to a practical application of this theory to the subjects connected with it; beginning with that of

Ink.

Cicero (Tuscul. 5,) has given a copious statement of the important benefits resulting to mankind from the

use of ink; but, probably they might, with more propriety, be ascribed to the *art* of writing, than to the *means* of exercising this art, of which ink is but one; though certainly it is not the least interesting among them.

The Latin name of ink, *atra*mentum, and the Greek name of *writing ink*, μέλανγραφικοὺ, strictly denote a *black* substance, and authorize us to conclude, that this was originally and exclusively the colour of the liquids employed for writing; though, afterwards, other coloured fluids were applied to the same purpose; and then to the names signifying *black* ink, or black matter, other words signifying *red*, *yellow*, &c. were *incongruously* united.*

It appears that the ancients had not, even in Pliny's time, become acquainted with our writing ink, or at least with the use of it as such, even though the black, produced by a combination of iron with the colouring matter of galls, oak bark, &c. was frequently brought under their observation by shoe-makers, who gave this colour to their leather, as they do at present, and by the very same means; it seems probable, also, that galls were used to dye black with sulphate of iron, at the time when Pliny wrote his comprehensive work, for in his 16th book, chap. 6, after mentioning that all trees which produce acorns afford *galls*, Pliny adds, that those of the oak *hemeris* (which he had previously mentioned as bearing the largest acorns) were the best, and most suitable for *tanning leather;* that those of the broad-leaved oak were lighter, and less esteemed; but that it moreover produces a sort of black galls, which were

* "Verum tamquam peculiare *nigro* colori esse censeo hoc *atramenti nomen;* quanquam pro pigmentis scriptoriis singulis, et diversi coloribus usurpatum sit." Caneparius. 191.

more useful in dyeing;* and these he mentions again in the next chapter, and in the 4th chapter of his 20th book also; where, after describing the different sorts of galls, he adds that they all possess similar properties and *dye hair* or wool *black*, "omnes capillos denigrant." That their colouring matter was combined with iron for this purpose, is not, so far as I recollect, expressly stated any where, but that Pliny was acquainted with the colour produced by such combination, is evident from the 11th chapter of his thirty-fourth book, in which, after mentioning the salt of copper (blue vitriol) as being frequently adulterated by that of iron, (green vitriol, which the Greeks call *chalcanthon*,) he observes that this adulteration might be detected, by impregnating paper (that of the papyrus) with an infusion of gall nuts, and then smearing it over with a solution of the cuprous salt, which, if so adulterated, would produce a black colour. ("Deprehenditur et papyro galla prius macerato: *nigrescit* statim ærugine illita.") But the knowledge which the ancients possessed of the production of a black colour by a combination of iron with galls, oak bark, &c. is demonstrated by the use which they made of a solution of iron, to give that colour to tanned leather. This solution, or the sulphate of iron, dissolved by water for that purpose, was generally called by the name of "atramentum sutorium,"† *shoe-maker's black*. The Greeks and Romans, indeed, had incorrect notions of the nature of the sulphate of iron, and supposed it to

* "Sed gallam *Hemeris* optimam, et coriis perficiendis aptissimam: similem huic lati folia, sed leviorem, multoque minus probatam; fert et nigram: duo, enim genere sunt: *hæc tingendis utilior*."

† This was afterwards used to signify bribery, and a person put upon his trial, and corruptly acquitted, was said to be "atramento sutorio absolutus," absolved by shoe-maker's black.

bear some relation to copper, as the moderns did long after; an error which occasioned it to be commonly called, as it is even at this time, *copperas*. Thus Pliny tells us (lib. xxxiv. cap. 12.) that the Greeks, in consequence of this supposed relation, had given the name of chalcanthum, to that substance which the Latins denominated atramentum sutorium; and after mentioning how, and the places where it was produced, its colour, transparent glossy appearance, &c., he adds, that being dissolved or diluted, it served the purpose of staining leather black.*

But, notwithstanding this knowledge of the black, produced by iron with galls and other matters, then employed for tanning skins, (among which were the pods of an Egyptian acacia, the cups of acorns, &c.,) no ap-application of this knowledge, for the production of *writing-ink*, appears to have taken place, when Pliny wrote his history; for in his thirty-fifth book, chap. 6, after mentioning the black pigment employed by painters, and describing it as being obtained like our lamp black, by burning rosin or pitch in places, which, he says, were constructed purposely to hinder the escape of smoke, he observes, that the *best* was obtained from torch wood, or pitch pine, though frequently adulterated by the soot collected in furnaces and bagnios; *and this he adds, is employed to write books.*† He afterwards adverts to the wonderful nature of the cuttle fish and its ink, (of which, and of the use made of it to conceal themselves when in danger, he had given an account in the

* "Græci cognationem æris nomine fecerunt et atramento sutorio: *appellant* enim chalcanthum: nec ullius, æque mira natura est."——"*Diluendo fit atramentum tingendis coriis.* Plin. xxxiv. cap. 12.

† "Laudatissimum eodem modo fit e *tedis:*" adulteratur fornacum, balinarumque *fuligine*, "*quo ad volumina scribenda utuntur.*"

29th chapter of his ninth book;) but observes, that no use was made of it as ink. "Mira in hoc sepiarum naturæ: *sed ex his non fit.*" In the same chapter, Pliny adds, that for the purpose of writing, the lamp black, or soot, was rendered much more useful by being mixed with gum, and for painting, by an admixture of glue —"perficiter librarium gummi, tectorium glutino admisto." And any person who will take the trouble of mixing lamp black with water, thickened a little by gum, may obtain an ink of no despicable quality in other respects, and with the advantage of being much less liable to decay by age, than the ink now in common use.

But though the Greeks and Romans in Pliny's time, were acquainted with no better writing ink, than that which I have just mentioned, the knowledge they had acquired of the colour resulting from a combination of gall nuts, &c. with iron, would naturally lead them to employ the black so produced, as ink; and probably after doing so, they would find motives to induce them gradually to adopt its use; as, indeed, they appear to have done; though I cannot discover from Caneparius, who has written a volume on the subject, any evidence of the time when this substitution began; we may, however, infer from Sir Charles Blagden's communication to the Royal Society, (in the Phil. Trans. for 1787,) that in the 9th century those who made it their business to copy manuscripts, used ink composed from iron and galls, though, probably, the use of it was not so general, as wholly to preclude that of *lamp black* or soot, in this way.* I shall, indeed, presently mention a com-

* That the use of lamp black in making ink, was not wholly laid aside when Caneparius wrote, appears by the receipt which he has given at p. 176, for a *portable* ink, to consist of one pound of honey, the yolks of two eggs, half an ounce of gum arabic in powder, as

position of my own for ink, of which lamp black is a principal ingredient, and which may, probably, cause the latter to be hereafter employed in a similar way; at least for purposes which may require a most durable and almost *indestructible* ink. Of the writing inks most generally used in the beginning of the 17th century, when the work of Caneparius was printed at Venice, he gives an account, between pages 170 and 179; and they appear to have consisted principally of galls, sulphate of iron, water, and gum, in different proportions, to which some persons added the bark of mountain ash, or the ripe berries of the privet; and others, the rinds, or peelings, of pomegranates; and these last he strongly commends, as contributing very much both to the *lustre* and *blackness* of the ink; and I have sometimes been disposed to adopt this opinion; but, probably, the good effects which I had occasionally observed from this addition, may have been manifested only when, from a defect, or want of the galls, the proportion of iron would have been too great without the pomegranate peels, which, indeed, will alone produce a good ink, with sulphate of iron.*

The best proportions among those suggested by Caneparius, seem to have been half a pound of sulphate of iron to one pound of galls, with a quarter

much lamp black as would render the mixture sufficiently black. These were to be well beaten, and mixed in a mortar, so as to make an uniform and solid mass; of which, when wanted, a little was to be dissolved in water. Even at this time, the Boors at the Cape of Good Hope are said, I think by Mr. Barrow, to write with soot and brown sugar mixed in water; and I have often seen such ink employed by farmers in North America.

* Having noticed some printed receipts, for making ink with pomegranate peels and sulphate of *copper, instead of iron*, I prepared such an ink; but the colour, as I had expected, was merely an olive brown, *not black*.

of a pound of pomegranate rinds, and about as much gum; but even ink so made, would have been more lasting, if not blacker, with a few ounces more of galls. He afterwards highly commends the addition of a little white sugar to ink. Some persons, he tells us, employed wine instead of water, which rendered their ink less liable to be spoiled by freezing; and to obviate this more effectually, Caneparius proposes an addition of brandy to the ink. He observes, at page 172, that some *ink-makers used the black liquor of the cuttle fish*, in addition to the other matters. ("Admiscen tatrum liquorum sepiæ piscis marini," &c.*)

* This wonderful genus, (*sepia*, or *cuttle fish*,) consists of eight species, of which some, inhabiting the ocean between the tropics, are very large, and provided with a terrible apparatus of arms or holders, beset with *suckers*, by which they seize and hold their prey. Each of the eight arms of the sepia octopus is said to be sometimes eight or nine fathoms in length, and strong enough to seize a boat and draw it under water; a circumstance which induces the boatmen of India always to carry hatchets to cut off these arms, if applied to their boat. All the species are provided with a dark-coloured fluid, (which in some is quite black,) secreted by a particular glandular organ, and contained in a membranous purse destined for its reception. This fluid they emit to obscure the water, when it is wanted to favour their own escape from danger, and, perhaps also, when, by concealing their approach, it may enable them with greater facility to seize their prey. This liquid consists of a mass of extremely minute carbonaceous particles, intermixed with an animal gelatine or glue, and capable of being so widely spread, that an ounce of it will suffice to darken several thousand ounces of water. The sepia officinalis, or most common species of this genus, and the sepia loligo, (calimary, or sea sleve) appear to have been eaten by the ancients, as they now are by the Italians; and the Lacedæmonian *black broth*, is supposed to have been made by boiling them whole together with their ink bag, the mucilage contained in it being well-tasted. Indeed, the sepia tunicata, inhabiting the Pacific Ocean, and frequently weighing one hundred and fifty pounds, is, according to good accounts, contro-

At page 177, Caneparius directs the composition of an ink powder, by mixing and grinding together galls,

vertible to very wholesome and palatable food; and even the dangerous sepia octopus is said to be eatable, though it has been supposed to possess an electric or galvanic power, like that of the torpedo, or of the gymnotus electricus, and to be thereby assisted in subduing its prey; as the sensations of persons seized, or touched by the arms of this animal, are stated to have been much more *painful* than any which mere mechanical violence of equal force could produce. When dissected, this animal is said to be highly luminous.

Having frequently heard and read, that the coloured liquor of the cuttle had been formerly employed as ink, I procured one of the sepia officinalis, and made trials of its ink, by writing with it on paper, and applying it to stain calico; upon the latter I could not fix it, so as to bear a single washing; but I have now before me, some writing performed with this matter, which bears date 28th of June, 1796, and which seems to be as black as it was at first, though the strokes of the pen are not uniformly black, the carbonaceous particles seeming not to have been equally dispersed through the gelatinous fluid; and this latter being liable to putrify, the black liquor in its *natural* state could not be long preserved for the purposes of ink; though the carbonaceous matter might easily be separated from the animal mucilage, and mixed with a solution of gum arabic, which would not be liable to putrefaction.

Caneparius supposes, p. 193, that Dioscorides had, besides indigo, intended to describe a *black* pigment obtained from India, to which Paulus Ægineta alluded in his seventh book, under the name of Melan Indicum, or Indian ink. As indigo had then been brought from Asia to Greece and Rome, it seems not unlikely that the pigment which we call Indian or Chinese ink, might also have come to the knowledge of Dioscorides. But, however this might have been, it seems to be now ascertained, and generally believed, that our Chinese ink is obtained from the black liquor of some of the species of sepia. I could adduce many authorities in support of this belief, but the following will suffice, viz. Cuvier, in the fifth volume of his Leçons d'Anatomie comparée, p. 262, after describing the structure of the cuttle fish, and the nature of its ink, observes, that the latter is not by much so black, in the common cuttle fish, as it is in that species which the French called *poulpe*

with about one-third of their weight of sulphate of iron, and one-fifth of gum, and the same quantity of alum; (which last is, I believe, now properly omitted in these compositions;) and in the following page, he describes an ink for staining linen, &c. which was prepared by putting iron filings and powdered galls into the strongest vinegar, and placing them over the fire, until so much of the metal had been dissolved, as would produce the required blackness. The fluid part of the mixture was then separated by straining, and thickened by gum. This composition, though differing in regard to the method of preparing it, resembles the prosubstantive black, from acetate of iron and galls, commonly employed at this time by calico printers.

At page 179, Caneparius describes a method of restoring the blackness of writings, which were become illegible by age, and this was by an infusion of galls in white wine, which he afterwards subjected to an unnecessary distillation, and then applied the liquor to the *faded letters*, by a sponge, or a little cotton, which, he

(*sepia* octopus) and he adds that " L'éncre de la Chine n'est bien certainement pas autre chose, que la production de quelque espéce de *poulpe* de ce pays la. Ce seroit donc, vainement qu'on chercheroit a l'imiter, par des mélanges artificiels. L'analyse chimique y a reconnu, un carbone tresdivisé, mélé à un gluten animal."

The following is from Paul Hermann's Cynosura, tom. i. part 17, p. 11. viz. "Sepia piscis est qui habet succum nigerrimum instar atramenti, quem Chinenses cum *brodio orizæ* vel alterius leguminis inspissant, et in universum orbem transmittunt, sub nomine atramenti Chinensis."

And in confirmation of this, M. Chaptal states, that " Dans les pays chauds, en Italie et dans le midi de la France, on emploie la liqueur de la *seche* aux mêmes usages et avec le même succès que la meilleure encre de la Chine." Chimie appl. aux arts, tom. iv. p. 300.

says, rendered them as distinctly visible as when first written. Prussian blue was not then known, and, therefore, the application of its colouring matter for this purpose (as recommended by Sir Charles Blagden) was impossible; and that being the case, the means suggested by Caneparius (excepting the distillation) were the best which could have been employed; and seem to indicate, that he must have justly imputed the loss of blackness in writing ink to the decay of its *vegetable*, and not of its *metallic* part.

Though two centuries have nearly elapsed since the publication of Caneparius's work, no improvement of much importance seems to have been since made in the composition of writing ink. The late Dr. Lewis, indeed, bestowed particular attention upon this subject; and his Philosophical Commerce of Arts contains some accurate, as well as judicious, observations relating to it; especially in regard to the use of logwood, with which Caneparius does not seem to have been acquainted, at least as an ingredient in the composition of ink.

The desired blackness of colour, as well as its durability, in this composition, depend entirely upon the proportions in which the vegetable colouring matter and the oxide of iron are united; though, among the different recipes which have been published, the variations are so great as to manifest either culpable ignorance in the authors of them, or great diversities in the quality of the galls, from which the colouring matter is generally directed to be obtained: in some of these recipes, equal parts of galls and sulphate of iron are directed; and in others, six times as much in weight of the former as of the latter. Certainly galls from different species of oak, and from different countries, vary much in their comparative proportions of colouring matter; and even among those which are commonly called the

best Aleppo galls, one pound of the heavy blue, or unperforated galls, will commonly prove equal to one pound and one half of the *white*, from which the insect has escaped, and which, from their having been longer upon the tree, with large perforated or open cavities, exposed to the weather, and particularly to rain, will have suffered a considerable loss of colouring matter. These two sorts of galls, as commonly imported, are are mixed together in nearly equal portions, and are then called *galls in sorts*, which are to be understood as meant by me, when the contrary is not expressed.

Of such galls, I think, from the results of numerous experiments, that three pounds will afford the most suitable proportion of colouring matter, for one pound of sulphate of iron, when the former is intended to be obtained exclusively from galls; and when logwood is to be employed conjointly with the latter, the galls may be diminished at the rate of one half of the weight of logwood. In regard to the proportion of galls to that of sulphate of iron, my opinion accords with that of Lewis, who found that three pounds of the former to one of the latter, commonly produced the best and most lasting ink. Ribaucourt, indeed, thinks two pounds of galls sufficient for one of sulphate of iron, and certainly with this proportion, an ink may be produced sufficiently black; but not so durable, as it would be with a larger proportion of vegetable colouring matter.

In regard to the use of logwood, Chaptal does not consider it as being capable of adding any thing to the blackness of ink, made with galls and sulphate of iron, in suitable proportions; but he thinks that it contributes to hinder a precipitation of the colouring matter, and that the ink, of which it is a component part, is, by its use, rendered more smooth, or *marrow-like*, (moëlleux) and the black in appearance more soft; and that the strokes

made with it by the pen are more clean. To me, however, logwood has always seemed to give additional body, or fulness, to the colour of ink, though it cannot be supposed to render it more lasting; for, by many experiments, I have found that neither on paper, or parchment, any more than on linen, or cotton, or, indeed, wool, was the black resulting from a combination of logwood and iron, of equal durability with that from galls and iron. And it may, therefore, be best, in making ink, to employ, as Chaptal advises, only half as much in weight of logwood as of galls. He thinks also, that the addition of sulphate of copper, in the proportion of one ounce to every fifteen ounces of galls, produces a good effect; that the bluish tint which accompanies ink when first made, even in the most suitable proportions, (until sufficient oxygene has been absorbed,) will be sooner overcome by this addition, and that it will also contribute to render the ink more lasting.

But of this last effect I am very far from being convinced; because it has been fully ascertained, by experiments which I have repeatedly made, that the colouring matter of logwood cannot be made so durable, upon either paper, wool, silk, linen, or cotton, when united to an *oxide of copper*, as it is with that of *iron;* and though, by producing a *dark blue* with copper, it may improve the shade of black resulting from the iron and galls, this blue, by fading sooner than the black, which logwood produces with iron, (when no copper is present,) must render the ink so much the less durable. I have here supposed the effect of copper to result exclusively from its union with the colouring matter of logwood, for with that of galls it can produce neither blue nor black.

M. Chaptal would reject the use of sugar in making ink, as being completely useless; for to him it did not seem

even to render the ink more glossy or shining; though such an effect has always been manifest to my apprehension. He has found no benefit by employing either vinegar, wine, or beer, instead of water, as a vehicle of the colouring matter of ink; indeed, he was persuaded, that beer did harm, by increasing the disposition of ink made with it to become mouldy.

M. Chaptal concludes from his numerous experiments in regard to writing ink,* that the best ingredients and proportions for composing it, are the following, viz. Two parts of galls in sorts, bruised, and one part of logwood chipped; these are to be boiled in twenty-five times their weight of water, for the space of two hours, adding a little water, from time to time, according to the evaporation. The decoction so made, he says, will commonly mark from three to three and an half degrees upon the hydrometer of Beaumé, equal to about 1022 of the common standard. At the same time, a solution of gum arabic is to be made with warm water, until the latter will dissolve no more of the former. This solution will mark fourteen or fifteen degrees, equal to about 1110. A solution of calcined sulphate of iron is also to be made, and concentrated so that it will mark ten degrees, equal to about 1071. And to this, as much sulphate of copper is to be added as will be equal to one-fifteenth part of the galls employed to make the decoction. The several matters being so prepared, six measures of the decoction are to be mixed with four measures of the solution of gum, and to this mixture, from three to four measures of the metallic solution are to be added, by a little at a time, mixing the several matters each time, by shaking. Ink so made will, he says, form no sediment: and he estimates the proportions of

* See his Chimie appliquée aux Arts, tom. iv.

solid matters contained in it to be 500 parts of gum, 462 parts of the extract of galls and logwood, and 481 parts of metallic oxides.

But though the hydrometer may enable those who will employ it, to obviate or correct the uncertainties resulting from the difference of quality in galls, some persons may wish to avoid the trouble of doing so, and choose rather to incur the risk of some little defect in the ink they may prepare, and for their satisfaction, therefore, I will mention the following, as being generally the most suitable proportions for composing the best and most lasting writing ink, viz.

Take of good Aleppo galls, in sorts, coarsely powdered, twelve ounces, and of chipped logwood six ounces; boil these in five quarts of soft water two hours, and strain off the decoction whilst hot; then put to the residuum as much boiling water as, when properly stirred, strained, and added to the former, will suffice to make the whole of the decoction equal to one gallon; add to this five ounces of sulphate of iron, with the same quantity of gum arabic, and two ounces of good dry muscovada sugar; let these be all dissolved, and well mixed by stirring.

I do not consider a calcination of the sulphate of iron, which Chaptal, Proust, and some others, have recommended, as of much importance; for though the ink may be thereby made to attain its *utmost* degree of blackness, almost immediately, the strong disposition which ink has to absorb oxygene from the atmosphere until saturated therewith, will enable it, without such calcination, to attain an equal degree of blackness, in a day or two, according to the temperature of the air, if the latter be allowed free access to it. I have omitted the sulphate of copper, for the reasons lately mentioned; and if any portion of that metal were deemed beneficial,

I should prefer verdigrise to the sulphate, the latter containing a much larger proportion of acid, than even the sulphate of iron, and being, therefore, more likely to render the ink corrosive.

Some persons have recommended the addition of indigo to ink; but, unless it be previously dissolved by sulphuric acid, it will be found to subside, even though very finely powdered; and, if so dissolved, this increased portion of acid will render the ink much more corrosive; and after all, the blue afforded by this combination, (as was formerly noticed in regard to the sulphate of indigo,) will not prove very durable.

Gum is highly useful to retard the separation, and subsidence of its black part, or compound of colouring matter and iron, previous to its application to paper, as well as to hinder it from spreading and penetrating too far into the latter, when applied to it.

As the acid part of galls is extracted more readily than the other soluble parts, especially when the water employed for that purpose is cold, and as ink, which, along with colouring matter, contains more than the ordinary proportion of this acid, is the least disposed to produce a sediment (for the reasons lately assigned,) some persons have recommended the making of it by *a cold* infusion of galls. But when this is done, the galls must be employed in a much greater proportion; and, even with this additional expense, there will be cause to fear that ink so obtained, may not prove so durable as other ink containing a full proportion of the less soluble, but more STABLE, part of the colouring matter of galls. It is, therefore, with good reason, that Lewis, Chaptal, and others, have recommended *boiling* to extract the *whole* of the soluble matter contained in galls; especially as oxygene will be absorbed during the ebullition, and this absorption will contribute to give the ink its full degree of blackness so much the more speedily.

Ink, in which the colouring matter of logwood bears a large proportion, will be made red by applying muriatic acid to it; this redness, however, will soon disappear, and the former blackness be restored, partly at least in consequence of the volatility of the acid.

It does not appear that any considerable advantage is gained by substituting any of the other acids for the sulphuric, to dissolve iron for making ink; though the case is different in regard to dyeing and calico printing.

I have already observed, that an excess of sulphate of iron produces ink of a *bluish* tint, which, if the excess be great, will, at no remote period, become yellow; probably, because the affinity of the metallic oxide for oxygene, not being counteracted by a sufficient portion of vegetable matter, the latter will gradually suffer a decomposition from the excess of oxygene absorbed, and at length the oxidated iron alone will remain. A similar effect will, indeed, take place, after a long course of years, even when there is no disproportion of iron; but it will be retarded by increasing the proportion of galls beyond that which produces the blackest colour; and, indeed, by such an increase as to make the ink incline considerably, from what is deemed a good black, towards a brownish purple.

But, unfortunately, that ink in which the proportion of galls is greatest, is the most disposed to become mouldy; a defect which it is difficult, if not impossible to hinder, in any considerable degree, so long as ink retains the mucilaginous part of the galls, which water always extracts along with the colouring matter. It has, indeed, been found, that by keeping a saturated infusion, or decoction of galls, six or eight months, more or less, according to the temperature of the atmosphere, and carefully removing the mouldy pellicle, when it

forms on the surface, from time to time, the mucilage will at length be wholly separated from the remaining part of the infusion or decoction, and no subsequent production of mouldiness will then take place therein; and if it be afterwards passed through a fine strainer, and mixed with a suitable proportion of sulphate of iron and of gum arabic, an ink may be formed, which will be exempted from the defect of mouldiness. It was, probably, in this way that the ink, sold in France under the name of *encre de Guyot*, was prepared; and Dr. Tarry has, in the Ann. de Chimie, tom. 74, given a recipe for preparing an ink on this principle. It must, however, be observed, that by this method of separating the mucilage from the colouring matter of the galls, a considerable portion of the latter will be also taken away and lost; and there is room to suspect, that the remainder, by its having been kept so long in a fluid state, will have suffered some degree of deterioration, tending to render the colour of the ink, when made with it, less durable. And, therefore, knowing that the mucilaginous part of the galls does not combine with the iron and colouring matter in the formation of ink, I thought it might be practicable and advantageous to separate the former from the latter, by adding just enough of *caustic* potash to the ink, to neutralize the sulphuric acid, and throw down the black compound of iron and vegetable colouring matter; and after separating this last by a filtre, or fine strainer, re-dissolving, converting it again to ink with sulphuric acid, sufficiently diluted, or with *distilled* vinegar, avoiding that which had not been *distilled*, as it would restore other mucilage almost as hurtful as that which this process might separate. And having produced an ink in this way, I found it quite unobjectionable, and free from all disposition to become mouldy.

Newman formerly recommended the adding of cloves to ink, in order to counteract its disposition to mouldiness: and the late Dr. Black adopted this recommendation, advising only, that the cloves should be powdered, and rubbed in a mortar with the mucilage of gum arabic, to render their essential oil miscible with the ink; and by this expedient he supposed that an ink might be obtained, which would be but little, if at all, subject to the defect in question. I did not, however, in repeating this experiment, find any considerable benefit from cloves, employed in this way, and therefore substituted camphire, which seemed to answer better, though it appeared to give the ink a bluish tint; but I have been since convinced, that neither these, nor any other means, will completely obviate the mouldiness in question, so long as ink retains the *mucilaginous* part of galls *in a liquid state.*

M. Chaptal observes,* that since the oxygenated muriatic acid has been found capable of discharging the colour of common writing ink, both from parchment and paper, without injuring their texture, it has been fraudulently employed to efface particular parts or words of deeds, contracts, and other writings, for which others have been substituted, leaving the signatures untouched; and that, in consequence of these frauds, the commercial part of society, as well as governments, became solicitous for the discovery of some composition, which might be employed instead of common writing ink, without its defects, and therefore, (being then minister of the interior of France, and possessed of great chemical science,) he, as might be expected, occupied himself particularly with that subject; and he states, that up to the then present time, the composition which had

* Chimie appliquée aux arts, tom. iv. p. 244.

been found most useful for this purpose, consisted of a solution of glue in water, with which a sufficient portion of lamp black, and a little sea-salt were intimately mixed, by rubbing them together on marble. This composition was made sufficiently thin (by water) to flow readily from the pen; and he describes it as being "*d'un trés bon usage;*" and capable of resisting the action, not merely of cold, but of boiling, water; and also of acids, alkalies, and spirit of wine; and attended with no inconvenience, but that of abrasion, by being rubbed. (" Elle n'a que l'inconvenient de s'estomper par le frottement.")

Though I have never made trial of this composition, I can readily believe M. Chaptal's account of its good properties; but I must observe, that it differs from the ink commonly used when Pliny wrote in nothing but the addition of sea-salt, (for which, as being less disposed to deliquate, I should think either salt-petre or sulphate of potash might be advantageously substituted,) and in the employment of *glue* instead of gum arabic, (which Pliny recommends,) to give the composition sufficient tenacity and consistency. Indeed, Pliny, as I lately mentioned, directs glue to be employed with lamp black instead of gum, when the atramentum or black mixture was intended to be applied as a pigment internally to the walls, &c. of houses. I have, indeed, found that when lamp black has been incorporated with common ink, by first rubbing the former in a mortar with a mucilage of gum arabic, the writing done with it could not be rendered invisible by the application of muriatic acid; and, doubtless, such an addition of lamp black would hinder the letters from ever becoming illegible by age, at least within any length of time which the paper and parchment could be expected to last. But ink made with this addition would require to be frequently shaken or stirred, as the lamp black would otherwise be apt to

separate and subside. Glue could not be advantageously employed with any ink containing tannin, for obvious reasons.

As all inks in which the colouring matter is mixed with an aqueous menstruum or vehicle, are liable to suffer injury by wetting, I resolved to make trial of the essential oil or spirit of turpentine, and to incorporate with it, as intimately as possible, a sufficient portion of finely-powdered lamp black; and having done so, I obtained an ink which proved to be sufficiently black, and flowed from the pen readily, and with a remarkably smooth and homogeneal effect. I have, indeed, now before me, several pieces of writing, for which this composition was employed, (dated at Kew, in September, 1799,) and the strokes of the pen, though fine, are as distinct and even as possible. Strong nitric and muriatic acids have been applied to different parts of the writing, without impairing the colour in the slightest degree; nor did boiling water cause the letters to run or spread. The most concentrated sulphuric acid, or oil of vitriol, being dropped upon the writing, and suffered to remain several days, was found to have nearly destroyed the paper, but not the writing. And I cannot conceive any purpose, depending upon the fixity, durability, and indestructibility of ink, which may not be answered by this composition; there being, as I am persuaded, no chemical agent, nor any length of time which can efface its impressions, without destroying the paper or parchment on which they are made.

In some parts of the East Indies, a permanent writing ink is formed, by dissolving the brownish black liquid contained in the oriental marking nuts, (semecarpus anacardium,) mentioned at p. 228 of my first volume. The solution is to be made by an alkaline lixivium, and afterwards neutralized by vinegar.

There are some few instances of inks said to be produced by vegetable colouring matters upon the basis of alumine, instead of iron; one of these, first mentioned by Ray, and afterwards by Linnæus, is from the poisonous berries of the actea spicata, or common black-berried herb Christopher. Linnæus also mentions the fruit of the empetrum procumbens, as affording another such ink. I believe, however, that neither of these can be lasting.

Barham, in his Hortus Americanus, mentions the pods of the mimosa juliflora, (improperly called poponax in Jamaica,) as affording a good ink on a similar basis. He says, "they soak some of the pods all night in water, then mix a little alum with it, and boil it to a due thickness, which makes a very fine black and strong ink," and he adds, that he had often made and written with it. Reflecting, however, upon the family and genus to which this tree belongs, I am persuaded that the black which it affords must be produced by iron, which might very easily be dissolved, partly by the astringent vegetable matter, and partly by the acid part of the alum contained in the infusion, while the latter underwent the *boiling* which is prescribed, if performed, as it doubtless must have been, in an iron vessel; and this, probably, is the fact also, in regard to the natural ink, which the inspissated juice of the old trees of the fagus castanea, Linn., is said to afford. The inspissation or evaporation of this being, doubtless, performed also in iron vessels; though Crell has supposed, that the juice of this tree naturally contains iron; but certainly it cannot contain it in any proportion sufficient to produce such an effect.

After this account of the various kinds of writing ink, (which I have made the more copious, because the

subject is generally interesting,) I shall proceed to the application of

The Black Dye upon Wool and Woollen Cloth.

Among the Greeks and Romans, *black was confined* to their *mourning* garments, and to those in which the priests sacrificed to the *infernal* gods; for to the *celestial*, this office was performed in *purple*, and to *Ceres* in *white*.* But in modern times, and among the more civilized nations of Europe, the use of black is much more extensive, it being worn at *all times*, by certain orders and professions; and by *all* orders and professions, at *some* times, as in public and private mournings; and, moreover, hats, and some particular garments, are commonly worn of that colour at almost all times; and it is, therefore, perhaps, the most important of all the colours given by dyeing.

I have already mentioned, that among the three primitive, or simple colours, blue is that which approaches nearest to black, and that the deepest and most perfect black may be produced on woollen cloth, merely by the accumulation, or condensation, of a sufficient quantity of indigo blue, even of that which is rendered the most lively and bright, by being combined with sulphuric acid. I have mentioned also, the method practised, more particularly by the famous dyers of the name of Gobelin, of dyeing black without either galls, logwood, or iron, in any state or form, merely by superadding to the woad or indigo blue, a *red* colour from madder upon the aluminous basis, and a yellow from weld, upon the same basis: indeed, the dyeing of wool or cloth *black*, without previously giving it a dark blue ground from

* See Bishop Potter's Antiquities of Greece, vol. i. p. 225, and ii. 196.—Cicero (in Vatinium) asks, "Quis unquam cœnavit *atratus?* Who ever went to a supper dressed in black?"

woad, was prohibited in France, by the regulations promulgated by the minister Colbert, excepting only coarse stuffs of little value, for which it was lawful to substitute a dark-coloured ground from the rinds of walnuts, or the bark of the roots of walnut-trees; and the regulations anterior to those sanctioned by Colbert, had required a madder *red* to *be superadded to the blue* ground, as an indispensable part of the black dye.

Black cloths which, in addition to the blue, had obtained the madder red, were called *mathered* blacks in this country; and the act of the 23d of his present Majesty, cap. xv. entitled "An act for rendering more effectual the provisions contained in an act of the 13th year of King George the First, for preventing frauds and abuses in the dyeing trade," declares, that if any persons shall thereafter "dye, or cause to be dyed, any cloths, bays, or other woollen goods of any kind, or sort whatsoever, as, or for, mather (madder) blacks, the same not being dyed throughout, in the *first place with woad and indigo*, every such person shall forfeit and pay the respective penalties" therein mentioned; and that "if any person shall dye, or cause to be dyed, any woollen cloth, as, or for, *woaded* black, the same not being woaded throughout, every such person shall, for every such offence, forfeit, and pay for every piece of such cloth, the sum of two shillings per yard." This act also directed, that all *mathered* black truly dyed, should "be marked with a *red* rose and a *blue* rose,' '(to signify the blue and red dyes which it had received,) and that all "truly woaded black throughout," should be "marked with a *blue* rose only;" and the application of these marks to cloths not truly dyed, according to this act, was made punishable by a fine of four pounds for each of these marks. This act is still in force, though, probably, not well observed or executed.

Hellot, in assigning the reason why one, at least, of these grounds is required, and why it is made unlawful to dye cloth *directly* from *white* to *black*, observes, (chap. xx.,) that to produce this colour from galls and sulphate of iron *alone*, so much of the latter would be necessary to saturate ("surmonter") the former, or as he expresses it, to produce an *ink in the wool*, that its fibres would be thereby rendered harsh and brittle.*—

* It has been long and generally believed, that cloths dyed black were more easily torn, or, according to the common expression, rendered more *rotten* than those dyed of other colours; and this defect was at first commonly ascribed to the acid part of the sulphate of iron, employed in the black dye; but afterwards, from observing the injury done to linen, &c. by iron moulds, the blame was transferred to the *oxide*, or, as it was then called, the *earth* of iron. Accordingly, the Dijon Academicians, in treating of this defect, state the following observation:—" On sait aujourdhui qui ce n'est *ni la causticité de l'acide*, ni la chaleur du bain, qui brulent, mais que *ces sont les parties terreuses du Fer, qui y restent et qui en se precipitants sur l'étoffe la rendent cassante*." Elémens de Chimie, &c. tom. ii. p. 293. To this I may add the following, by M. le Pileur d'Apligny, viz. " M. Hellot a fort bien observé qu'un drap teint en noir, sans pied de bleu, ni de racinage, demande une plus grande quantite de cuperose, qui rend l'étoffe assante; et j'ai remarqué aussi, que lorsqu'on fait dissoudre de la rouille de fer, dans du vinaigre pour le jaune, ou le noir, des toiles peintes, la toile est *sujette a se dêchirer, dans les endroits ou ces couleurs sont appliquées*, lorsqu'on n'a pas eu l'attention d'écumer la dissolution, pour enlever la terre la plus grossiere. *C'est a cette terre qu'il faut attribuer le défaut des étoffes teintes en noir, de se casser facilement, et non pas à l'acidité du sel de vitriol*, ni a aucune cause, qui les brule, suivant l'opinion du vulgaire."—L'art de la Teinture de fils et des Etoffes de Coton.

That there is some foundation for the supposed greater rottenness of black cloths, than of those with other colours, I am disposed to admit; but, doubtless, in many instances, the defect is principally occasioned by the practice of applying the black dye to cloths which have previously undergone and been injured by certain dyeing operations, intended to produce other colours, which, having proved faulty, were fit only to be made black.

(" Il faudroit une grande quantité de cuperose, qui non seulment rudit l'étoffe mais que la rend cassante," &c.) He thinks, however, and with reason, that where galls and sulphate of iron are intended to form a part of the black colour, the madder red may be spared, if the very *deep blue*, required by the French regulations, and called " *bleu pers*," had been faithfully dyed. And, indeed, broadcloth so dyed, may be made to acquire a black in every respect unexceptionable, by boiling it two hours in a decoction previously made, from about one-seventh of its weight of galls and as much chipped logwood, afterwards passing it for another two hours through a solution of one-tenth of its weight of sulphate of iron, and keeping the solution at a scalding heat only. Most dyers content themselves with using a smaller proportion of galls, and making up for this deficiency by increasing the quantity of logwood, and by adding also a portion of sumach.*

For coarser cloths, and cheap woollen stuffs, the blue ground from woad, or indigo, is now commonly omitted, and its place badly supplied by one from logwood, and either sulphate of copper, or verdigrise; or the latter is dissolved with the sulphate of iron, to convert a part of the colouring matter of logwood into a blue dye. But the employment of *copper in any form with logwood, as a dye for wool, or woollen stuffs, ought to be, and in fact is, prohibited*, by the act of the twenty-third year of his present Majesty, lately mentioned; which declares,

* Some dyers think they obtain a perfect black with more ease and certainty, by boiling deep blue broadcloth two hours in a decoction of galls, then passing it through a warm solution of sulphate of iron, then through a hot decoction of logwood, then a second time through the solution of iron, and again, if necessary, through the logwood liquor; and repeating these alternate applications until the desired colour shall have been produced.

that any person who shall "use, or cause to be used, any logwood, or logwood liquor, in dyeing *blue*, any cloths, bays, or other woollen goods of any kind, or sort soever, shall, for every such offence, forfeit and pay the sum of *twenty pounds*, for every piece of such cloth, &c., in the dyeing of which, any logwood, or logwood liquor, shall have been made use of, as aforesaid." This prohibition, which is, I fear, rarely, if ever, now enforced, relates merely to the use of logwood in dyeing *blue;* and for this colour it is always employed with some preparation of *copper*, which, as a basis for the colouring matter of logwood, can produce none but a blue, and one which is a very fugitive colour, especially on wool and woollen cloth. The using, therefore, of either verdigrise, or sulphate of copper, even in the dyeing of *black* with logwood, ought to be considered as an infringement of the act; it can produce nothing like a black or blue colour with galls, sumach, or any other vegetable matter, commonly employed for this purpose, and its only effect, and, indeed, the only purpose which it is intended to answer, is that of producing a logwood blue, by uniting, as it does exclusively, with the colouring matter of this wood, and by the very dark blue resulting from that combination, rendering the black at first more *intense*, though it afterwards changes to a rusty brownish colour, much sooner than it would have done if no preparation of copper had been employed, and if the colouring matter of the logwood had been applied to the cloth, in conjunction with an iron basis alone; it having been demonstrated, by experiments which I have made repeatedly, that the logwood colour is much more permanently fixed upon wool, silk, linen, and cotton, by the latter basis, than by any preparation of copper.

Pœrner, indeed, pretends, that equal parts of sulphate

of copper and logwood, will dye upon woollen cloth a perfect black, capable of sufficiently resisting the impressions of the air, &c. He admits, however, that the use of so great a proportion of sulphate of copper ought to be avoided, on account of its being more corrosive than the sulphate of iron; and for this reason he proposes to employ only one part of the former to two or three of the latter, with a suitable quantity of logwood; which, he says, will not injure the cloth, and will produce a perfect black without the aid of a blue ground. I have, however, tried sulphate of copper with logwood, not only in equal, but in various other proportions, without having been able to produce any thing like a perfect black, even in appearance, and much less a black sufficiently permanent. With sulphate of iron and logwood, indeed it is not difficult to produce a full and deep black; but it certainly will not prove so lasting as the black with sulphate of iron and galls, or sumach, either alone, or with a moderate proportion of logwood; which last, certainly improves the appearance of the black, dyed from galls and iron, by rendering it more intense, glossy, and soft, or *velouté*, as it is expressed by the French.

All black cloths, for the dyeing of which a large proportion of logwood has been employed, may be *reddened* by the application of muriatic acid. Lime-water obstructs the production of a black by logwood and sulphate of iron, though a small proportion of potash favours its production.

Hats are dyed *without* a blue ground from indigo, by galls, logwood, and sulphate of iron; and for these, as well as for woollen cloths, the vegetable colouring matters are applied *first*, and the mordant, or sulphate of iron, *afterwards*, contrary to the practice observed in dyeing other colours. A peculiarity which has been ascribed to a belief, that the sulphate of iron, if first

applied to cloth, not impregnated with the vegetable colouring matter, would act more injuriously upon its fibres, than it does by a subsequent application; though the experiments which I have made do not convince me that this belief is well founded in any case, and more especially where the cloth has been previously dyed blue with indigo.

Probably, the practice has arisen, though without a proper knowledge of the motive, from the very little affinity which subsists between the iron contained in the sulphate of that metal and the fibres of wool, until they have imbibed a portion of vegetable matter. There is, as I stated in my first volume, a very marked attraction between the oxide of iron and the fibres of linen or cotton; but this oxide is much more strongly attracted by the vegetable colouring matter, than by the fibres of wool, and, therefore, it has been found most advantageous to impregnate the latter with this colouring matter first, and afterwards to apply the solution of iron; and even when this has been done, it is found very difficult to render *white* cloth *black*, by the mere application of galls and sulphate of iron, unless these applications are made repeatedly; though it may be done readily where the cloth has previously received a blue ground; or where the effect of the galls and iron is assisted by adding to it the purple, blue, or violet colour, of logwood. Lewis, in his Philosophical Commerce of Arts, observes, that "vitriol, (meaning sulphate of iron,) and galls, in whatever proportions they are used, produced no other than browns;" and that "logwood is the material which adds blackness to the vitriol and gall brown;" but that "on blue cloth, a black may be dyed by the vitriol and galls only;" though, even in this case, as he says, the logwood deepens the colour. This observation is, however, only true, in re-

gard to the *single* application of galls and sulphate of iron; which, whether the iron or the galls be first applied, and the other superadded, will at most only produce a brownish black on white cloth; manifestly, because the latter does not at *once* imbibe enough of the iron to answer the purpose; but by renewed applications of iron and galls alternately, a good and lasting black may be obtained, without either a blue ground, or the co-operation of logwood.

About the year 1753, Bergman strongly recommended a method of dyeing cloth black, after it had received a blue ground, by first boiling it for two hours in a bath with one pound of sulphate of iron and half a pound of tartar for six pounds of cloth, (taking care that the tartar should be all dissolved before the sulphate was added,) and, after having rinced the cloth, dyeing it in a separate bath, with a sufficient portion of the arbutus uva ursi, or bear-berry; though this, without the blue ground, would not, as Lewis has observed, afford a black colour, unless assisted by logwood.

Berthollet (tom. i. p. 126) quotes Mr. Delaval, as having stated, (in his Experimental Enquiry, &c.,) that by a simple dissolution of iron in a decoction of gall-nuts, he had not only produced the blackest and most durable ink, but that, having immersed therein both silk and woollen stuffs, without adding any acid, he had dyed them of the *deepest and most permanent black.* All this, however, must have been subsequent, by several years, to my communication upon this subject to the Royal Society, of which he was a member; and if he did not rely solely upon that communication, but actually performed what is thus stated, he must have been fortunate in dissolving so *exactly* the proportion of iron, necessary to produce these *excellent effects;* an operation which, after I had at first accidentally succeeded in

performing it, I found liable to so many failures, from the difficulty of ascertaining, at any time, how much of the metal had been actually dissolved, that I have long ceased to expect that it can ever be adopted with advantage by dyers.*

I have mentioned, at p. 226 of my first volume, that a fine lasting black, without iron or any other basis, might be dyed upon blue cloth, from a species of lichen, called *rags*, or stone rag in the North of England, (the lichenoides pulmonium reticulatam vulgare marginibus peltiferis, of Dillenius); and if this could be readily and copiously obtained, it would, probably, deserve to be preferred to madder and weld for rendering blue cloth black; and, indeed, I have found, that the brownish yellow which alder bark affords upon the aluminous basis, may, for this purpose, be advantageously substituted for that of weld.

Of the application of the Black Dye to Silk.

The fibres of silk not being organized like those of wool, do not so readily admit the black dye as the latter. Dr. Lewis (in his Philosophical Commerce of Arts) observes, that "woollen and silk are both dyed of a permanent deep black, but with this difference, that what the woollen dyer effects by three or four dip-

* The best, and, perhaps, only method of doing this, would be first to ascertain, as nearly as possible, the quantity of iron in its metallic state, which will produce the best effects when *totally* dissolved by, or with the soluble part of a given quantity of galls; but it would be highly inconvenient, and, in several respects, disadvantageous, to wait long enough for this *complete* dissolution of the iron, unless it were first brought into the state of *iron filings;* which, for general use in dyeing black, would be attended with more trouble and expense, than any advantage to be expected from this change seems likely to compensate.

pings of the cloth, in his dyeing liquor, the silk dyer scarcely obtains from twenty or thirty dips."

Though raw silk imbibes the black dye with as much facility as that which has been deprived of its gum, yet, when dyed, the black appears less intense and less fixed in the former than in the latter; and it is, therefore, made previously to undergo the usual boiling, with one-fourth or one-fifth its weight of soap, during three or four hours: by this operation, indeed, silk often loses nearly one-fourth of its weight, but this loss is more than compensated by that which it gains from the black dye.

As the affinity of silk with the soluble parts of galls is greater than with the iron contained in a solution of the sulphate of that metal, it is thought most advantageous to begin by first applying the former; and for this purpose about one-half as much in weight of Aleppo galls as of the silk to be dyed, is boiled in a suitable proportion of water, three or four hours, after which, the decoction having been left to settle, the fluid part is separated from the sediment, and the silk macerated therein twenty-four hours, more or less, according as the impregnation is intended to be more or less copious; and being afterwards dried and slightly rinced, the silk is immersed in a solution of the sulphate of iron moderately warmed, and kept therein with the usual management, until the colouring matter of the galls has nearly saturated itself with the oxide of iron; after which it should be rinced and immersed, &c. in a warm decoction of logwood; and having there imbibed as much of the colouring matter as may be disposed to unite with it, the silk is to be again immersed in a solution of iron, then rinced, and again transferred to the decoction of galls, repeating these alternate immersions, &c. until the desired colour shall have been produced.—Some

dyers think it expedient, or at least beneficial, to employ, for dyeing silk black, about one-sixteenth of its weight of verdigrise, which may be either mixed with the solution of sulphate of iron, or with the decoction of logwood. Iron dissolved by the pyroligneous or acetous acid, is, in some respects, preferable to the sulphate of that metal.

By repeated macerations in the decoction of galls, and drying it between each of them, silk may be made to imbibe an increased proportion of their soluble matter, and having done this, it will attract an increased proportion of the oxide of iron, and thus acquire nearly a fourth part more in weight than it originally possessed, before its gummy covering had been separated by the boiling with soap. But the colour produced by this excess or superfluity of the black dye, is not commonly so perfect, or so permanently fixed, as it is when no such excess has been employed.

In addition to other means, and in order to improve their effects, silk dyers often provide themselves with what is called a black vat, (or *tonne au noir*, by the French,) composed of ingredients, differing considerably in different places; of which, however, the principal are vinegar, sour beer or cider, and oatmeal in water, with alder-bark, sumach, oak-bark, and sometimes galls; to which old iron hoops, or other thin pieces or minute divisions of that metal are added, and left to undergo a gradual dissolution, by the joint action of the acetous acid, and of that contained in the acerb vegetable matters just mentioned, or others possessing similar properties. The longer these mixtures have been made, the better they are found to answer the purpose for which they are intended. At Genoa (which has long been celebrated for its black dye) and other places on the continent, such vats have been made to subsist for ages, being

replenished, from time to time, by additions of the several ingredients, (some of them, probably, useless,) as fast as those formerly supplied may appear to have been exhausted.

The black dyed at Genoa upon velvet, and also upon a thinner sort of woven silk, to which I applied strong muriatic acid, appeared to have been produced with some, though not a large proportion of, logwood, and not to have received any blue ground from indigo or woad; and, indeed, this ground, though some persons have recommended it, is, I believe, now rarely given any where in dyeing of silk black.

The Chinese are said to improve their black dye upon silk, by passing it, when dyed, through a bath containing at the rate of one pound of starch, with half as much of the oil of linseed, or of rape, or hemp-seed, for every five or six quarts of water.

M. Berthollet (tom. i. p. 16.) has described a process, communicated to the Academy of Lyons, in 1776, for dying silk, by M. d'Anglês; but, on account of its length, I beg leave to refer my readers to that description, should they desire to know more of it.

Of the application of the Black Dye generally, to Cotton or Linen, either woven or spun.

The late Dr. Lewis, after mentioning the difficulty which attends the application of the black dye to silk, adds, that "the dyer of linen and cotton thread, however he prolongs the operation, or repeats the dippings, is unable to communicate to the thread a blackness that shall endure wearing." That there was some foundation for this observation at the time when it was made by Dr. Lewis, I am disposed to admit; though it must have resulted chiefly from the *improper methods* employed to communicate the black colour to these sub-

stances; for certainly the oxide of iron has more affinity, and unites itself more readily and permanently, with the fibres of linen and cotton, as is daily observed, in what are called iron-moulds, and in the buff colours produced by it, than it does with the fibres of either wool or silk; and, indeed, more permanently than any other basis is known to do; and there being a marked attraction between this oxide and the colouring matter of galls, sumach, &c., the black produced by these means, might well be expected to prove as durable on linen or cotton as on wool; and probably the only reason (in addition to the improper methods of dyeing) why it has not been thought so, is, that linen and cotton are subjected to occasional washings with soap, which is rarely applied to wool and silk when dyed black. Hitherto the dyers of cotton and linen have been accustomed, like those of wool and silk, to apply the vegetable part of the black dye *first*, and the solution of iron afterwards; thereby inverting the order observed in regard to other adjective colours, but with much less reason for doing so than the dyers of wool and silk have; at least, if the results of my experiments are not very fallacious.

It is notorious that the calico printers, when they wish to produce any adjective colour, by the aid of iron or its oxide, as a basis, invariably begin by applying the basis (commonly the acetate, or the pyrolignite of iron) separately to the calico, superadding the vegetable colouring matter afterwards; excepting only in those cases where a less permanent prosubstantive black or other colour is applied, for which the basis or mordant is previously mixed and combined with the vegetable colouring matter. And it is well known that the black and other colours given by calico printers, from sumach, madder, weld, quercitron bark, &c. upon an iron basis, applied first and *separately*, are much more lasting than

the same colours produced in a different manner by the ordinary dyers. And it has not, I believe, been found that the colours produced by calico printers, upon an iron basis, separately and previously applied, had injured the texture, or shortened the wearing of the calico, any more than colours given by the aluminous basis, at least when the acetate or pyrolignite of iron had been duly prepared and applied; though it must be admitted that iron, in a certain state of oxidation, if accumulated in or upon the fibres of linen or cotton, will render them brittle by impairing their flexibility. Of this fact I need only give the following instance or illustration: Having more than twenty years ago prepared two solutions, one of the green sulphate, and the other of the nitrate of iron, and having thickened them by suitable additions of powdered gum arabic, I marked an equal number of shirts and pocket handkerchiefs with each; and leaving them to undergo the usual course of washing and wearing, I observed, from time to time, the comparative effects of these different preparations of iron. The letters which had been marked with the sulphate, soon became of an even, smooth, pale yellow colour, which did not sensibly diminish, either in quantity or appearance, by any subsequent washing, nor did the parts or fibres of the linen to which this sulphate was applied appear less flexible, or ultimately prove to be in the slightest degree less durable than the other parts generally. But the effect of the nitrate of iron was very different, as the letters produced by it were of a brownish orange colour, with a rough unequal appearance, and the fibres of the linen, impregnated with the oxide, were so manifestly rigid, that I was not much surprised at finding holes produced, instead of the marks or letters, after a few washings. It appeared in this case, that the nitric acid had not only produced a much higher degree

of oxidation, in the iron dissolved by it, but had combined with a larger proportion of the metal; so that, in addition to the greater oxidation, there was an accumulation of the oxide, where it had been applied to form the letters or marks; and the corroding influence of this accumulation was, doubtless, augmented by further and continued absorptions of oxygene from the atmosphere.

From the results of this and other experiments, I have long been convinced, that a nitrate of iron cannot be directly applied to the fibres of linen or cotton, without producing injurious effects, unless it be much diluted, and very minutely divided; or unless it be mixed with a carbonate of potash, or some other matter suited to obviate the rigidity and corrosive influence which it would otherwise occasion. It has, indeed, long been a practice among calico printers, to dissolve iron by aquafortis, and afterwards mix the solution with a decoction of galls, to produce a prosubstantive black for topical application. By which mixture, the nitrate of iron is deprived of a part of its oxygene, and the oxide so much divided as to hinder, in a great degree at least, the accumulation and consequent rigidity before mentioned. Though there has often been some reason to think, that even this application was not innocent, in regard to the fibres of the calico blackened by it.

There is, however, no cause to fear this sort of injury from a *direct* application of the acetate, or the pyrolignite of iron, in the usual ways, as a basis for the colouring matter of galls, sumach, &c.; and I am confident, from the results of many experiments, that being so applied, (in the manner, and with the precautions mentioned between pages 233 and 237 of my first volume,) there can be no difficulty, afterwards, in producing a *full and permanent black*, by dyeing the linen or cotton, which has received this basis, with a suitable portion of

galls, with or without an addition of sumach, and even without the co-operation of a blue ground, (from indigo,) which is commonly thought necessary, at least for the finer and more costly cotton, or linen goods, intended to be made black: when linen and cotton have been so dyed, the colours may be more strongly fixed, by passing them through a weak solution of blue.

It may be proper, after having suggested what I consider as a decided improvement in the mode of applying the black dye to linen or cotton, that I should notice the methods most generally practised and approved for imparting that colour to these substances. M. le Pileur d'Apligny, (in his "Art de la Teinture des fils et étoffes de Coton,") describes the process most esteemed and practised for this purpose at Rouen; and by his description it appears that cotton yarn, and linen thread, are first dyed blue with indigo, and afterwards galled; employing a quarter of a pound of gall nuts for each pound of yarn or thread; they are afterwards macerated, and and worked by hands, three several times, in the liquor of the black vat, drying them between each of these macerations; and being finally well rinced, they are dyed with a quantity of galls and alder bark, sufficient to saturate the iron applied by the liquor of the black vat. To soften the black so produced, the thread and yarn are commonly passed through a remnant of weld liquor, and afterwards through a bath of warm water with which linseed oil has been mixed and well stirred; employing for this purpose at the rate of one ounce of oil for each pound of the dyed thread or yarn. This employment of linseed oil, gives a soft glossy appearance to the black dyed upon linen and cotton, and it also renders the colour more intense and durable; and it should always be so employed, when linens and cottons have been dyed black, in the manner which I have just recommended,

i. e. that of first applying the acetate or pyrolignite of iron, and afterwards the colouring matter of galls and sumach. But care must be taken not to withdraw the linen or cotton yarn from the mixture of oil with water, until, by suitable management, the oil has been equally dispersed and applied to the dyed substance. For cotton velvets, indeed, and piece goods, it will be advisable first to apply the oil generally, over the surface, by a *brush*, and afterwards favour the spreading and absorption of it equally by passing them through warm water. Goods which have been dyed with a pyrolignite of iron, must be afterwards well aired, lest they should retain the unpleasant smell which accompanies that acid.

M. Vitalis, (see Manuel du Teinturier sur fil et sur Coton filé, p. 127,) strongly recommends the following process for dyeing black upon thread and cotton yarn, viz. Let them be first galled, employing from two to three ounces of galls to each pound of thread or yarn, and then macerated in a warm pyrolignite of iron, marking from five to six degrees upon the aréomètre of Beaumé, equal to about 1·040 of the common standard. After this impregnation, they are returned again to the decoction of galls, and afterwards to the pyrolignite of iron, replenishing each of them, from time to time, until the proper colour shall have been produced; which, in his estimation, will not require more than five ounces of galls, and sixteen ounces of the pyrolignite of iron, (of the strength just mentioned,) for each pound of thread or yarn: after which the latter are to be rinced, dried, and impregnated with linseed or olive oil, in the manner lately described.

The most common method of dyeing cotton black, at Manchester, has, at least until very lately, been that of first making it imbibe the colouring matter of galls, or sumach, and then saturating this colouring matter

with the liquor of the black vat; then passing it through a decoction of logwood with verdigrise; and repeating these impregnations until the desired colour was produced, but always drying the cotton between each. Now, however, the pyrolignite of iron is frequently substituted for the liquor of the black vat, but not, as I believe, applied previously to the vegetable colouring matter.

M. Hermbstaedt, of Berlin, has lately recommended, (in the Biblioth. Phys. Œconomique, an. xiv. No. 2,) a method of dyeing black upon cotton, by applying to the latter a mordant consisting of the oxides of iron and copper, precipitated from solutions of the sulphates of those metals, and heated so as to make them absorb a maximum of oxygene; after which, they are to be dissolved in the pyroligneous acid; the cotton being impregnated with this mordant, is to be dyed with galls, sumach, logwood, &c. But having already stated that the oxide of copper can be of no use in producing a black colour, otherwise than by combining with the colouring matter of logwood, and that the *blue*, which it forms by that combination, is more fugitive than the *black* which logwood forms with the oxide of iron, when no copper is employed at the same time, it can hardly be necessary for me to observe, that M. Hermbstaedt's mordant is faulty, in as much of it as relates to the oxide of copper, of which the seeming good effect cannot be lasting.

Of the application of the Black Dye, topically and prosubstantively to Calico, &c.

I have already, in several parts of this work, and particularly at pp. 261 and 262 of my first volume, mentioned the method employed in the East Indies to produce black figures or stains, upon calico, which has

imbibed the colouring matter of the terminalia chebula, partially or topically, by applying to *it* a solution of iron by the acetous acid; and I have in other parts, and especially between pp. 278 and 281, of the same volume, described the opposite method employed by European calico printers, of communicating similar figures or stains to calico, by *first* printing or applying the solution of iron (by the acetous or pyroligneous acid) to the calico, and afterwards superadding the vegetable colouring matter, (commonly from madder or sumach,) by a dyeing process. It, therefore, only remains for me to offer some observations respecting the application which it is often highly convenient to make in calico printing, of the matters affording writing ink prosubstantively, or in a state of combination, instead of either of the *other* methods of applying them *separately*.

Forty years ago, some calico printers, as I was then informed, knew that the colouring matter of galls, produced a more permanent *prosubstantive*, or, as they termed it, *chemical* black, when combined with iron dissolved by *aqua-fortis*, than it did by any other preparation of that metal with which they were acquainted. No one, however, then appeared to suspect the cause of this increased permanency, though it will now be readily understood to have resulted from the greater degree of oxygenation which the iron had acquired from this acid; but, unfortunately, it also acquired properties which were sometimes found to have injured the texture of the calico stained by it; especially when the nitrate of iron had been employed in such proportions as were suited in other respects to produce the best and most durable colour; and when the composition, after its application, was, as is usual, dried in places *artificially heated.* The use, however, of this composition, has subsisted until the present time; and

the following is, I believe, the most approved method of preparing it, viz.

Take single aqua-fortis, or nitric acid of the specific gravity of about 1·260, and let it dissolve iron until saturated therewith; and having at the same time made a decoction of the best galls, of which each gallon should contain the colouring matter of two pounds of the nuts, mix these together, in the proportion of eight ounces of the solution, or nitrate of iron, to each gallon of the decoction, and let the mixture be properly thickened, according to the method in which it is intended to be employed, or applied; if by the pencil, with gum tragacanth. The mixture, if made with ten, or even twelve ounces of the nitrate of iron, instead of eight, will work more pleasantly, by affording neater and better defined impressions, and with some improvement of the colours; but there would then be danger of its hurting or weakening the fibres of the calico. The black produced by the mixture just described, is sufficiently lasting for all the ordinary uses of printed calicoes, and unobjectionable in regard to its appearance; and were it always *innocent* in regard to the texture of the cloth, there would be no great need to seek for any other. I ought to observe, that instead of water, some persons think it better to employ vinegar to extract the colouring matter of galls.

A composition for this purpose, is not unfrequently made, by adding to each gallon of the decoction of galls, twelve ounces of the sulphate of iron, (instead of the nitrate of that metal,) and boiling the mixture for an hour, or an hour and one half, by which it will gain a considerable portion of oxygene, and with it a deeper, and more permanent black colour. This composition has been, and I think justly, deemed harmless, in regard to the fibres of the cotton; though when thickened with flour, for printing by the block, it does not unite

therewith permanently; but in a day or two separates, or *parts*, in the language of the printers, so as not to be capable of adhering equally and properly to the block. By calcining the sulphate of iron, previous to its mixture with the decoction of galls, the subsequent boiling, except for a few minutes, would be rendered unnecessary, and the iron would become even more oxygenated than by the boiling. Some persons employ a portion of the colouring matter of logwood, conjointly with that of the galls, which renders the black more intense at first; but this effect, or *addition* of colour, will not be so permanent, as the black resulting from the combination of iron with the soluble part of galls.

Some years ago, I purchased of a calico printer, possessing great knowledge of the principles and practice of his art, the secret of a composition which he had employed with success, as a prosubstantive black, and which, as far as I can judge from experiments upon a small scale, deserved the high commendations which he bestowed upon it; and though I have never obtained the smallest pecuniary advantage from this purchase, in any way, I will here *give* the full benefit of it to the public. The following was his recipe, with some abreviations of language, viz.

Take two pounds of the best mixed galls in powder, and boil them in one gallon of vinegar, until their soluble part is extracted, or dissolved; then strain off the clear decoction, and add to the residuum of the galls as much water as will be equal to the vinegar evaporated in boiling; stir them a little, and after allowing the powdered galls time to subside, strain off the clear liquor, and mix it with the former decoction, adding to the mixture six ounces of sulphate of iron; and this being dissolved, put to it six ounces more of sulphate of iron, after it has been previously mixed with, and dissolved

by half of its weight of single aqua-fortis; let this be stirred, and equally dispersed through the mixture, which is to be thickened by dissolving therein a sufficient quantity of gum tragacanth, (of which a very small proportion will suffice.) Calico after being printed or pencilled with this mixture, should, when the latter is sufficiently dried, be washed in lime water, to remove the gum and superfluous colour, and then either streamed or well rinced in clear water.

This composition has not been found to weaken, or injure, the texture of calico printed or pencilled with it, and the colour is thought unobjectionable in regard to its blackness and durability.

I ought here to mention, that when sulphate of iron is mixed with aqua-fortis, the letter undergoes a decomposition; the oxygene of the nitric acid combining with the iron, and raising it to a much higher degree of oxidation; and that the result of these operations is the production of a fluid which has the consistence, and smooth appearance of oil, and which, (though the name may not be quite unexceptionable,) I will call a nitro-sulphate of iron. I have, however, been induced to believe, from several trials, that a better prosubstantive black than either of those here mentioned, or indeed than any other within my knowledge, may be formed, by taking a decoction, containing in each gallon the soluble matter of two pounds of the best galls in sorts, and, when cold, adding to it for each gallon twelve ounces of sulphate of iron, which had been previously mixed with half its weight of single aquafortis, (of which one wine pint should weigh about twenty ounces,) and, by the decomposition just described, converted to the nitro-sulphate of iron just mentioned. By thus employing twelve ounces of sulphate of iron, oxygenated by nitric acid, instead of six ounces of the latter, with six

ounces of the green sulphate in its ordinary state, an improvement in the colour seems, by my experiments, to have been invariably produced, and without any corroding or hurtful action upon the fibres of the cotton.

It having appeared to me, some years ago, to be highly expedient that the *comparative* degrees of stability and permanency, of the black colours, which galls, myrobalans, sumach, and logwood, were capable of affording with iron, should be ascertained; and knowing that each of them, with *certain* proportions of this metal, was capable of affording a blacker and more lasting colour than with any other less suitable proportion; I projected and executed the following experiments, as being eminently adapted to manifest the truths which appeared so desirable.

I prepared half a pint of a decoction of galls, which was made to contain the soluble matter of two ounces of the powdered nuts in sorts, and having ascertained the specific gravity of this decoction, I prepared a like quantity, and of the like specific gravity, of the decoctions of sumach, logwood, the fruit of the terminalia chebula of Retz, (or yellow myrobalans of the shops,) and also of the ash-coloured pear-shaped fruit, of another species of myrobalans, then recently imported from India, and which I take to be the terminalia belerica of Roxburgh*. At the same time I prepared what I thought a sufficient quantity of the nitro-sulphate of iron, recently described, by mixing six ounces of the green sulphate, with three ounces of aqua-fortis; and having

* They could not have been the fruit of the phyllanthus emblica, as some persons then supposed, because the latter is described by Loureiro as being *three* celled and *two* seeded, whilst the stony shell of the fruit under consideration, had but *one* cavity or cell, with a *single* kernel.

properly thickened the several decoctions with equal portions of gum tragacanth, I, with a suitable glass measure, put into each of them two drachms of the nitro-sulphate of iron, and having mixed it equally, I applied a little of the five several decoctions, or mixtures, to *one* end of a long strip of white calico, taking five strips for this purpose, and appropriating one of them exclusively to each of the several decoctions or mixtures. Each of these *first* applications was followed by twenty-four others, all made in succession, but only after one scruple of the nitro-sulphate of iron had been added to each of the several decoctions, and well mixed with it previously to any *new* application. In this way, thirty scruples of the nitro-sulphate of iron had been added at twenty-five different times, to each of the five mixtures, when the last application of each to the calico was made, and each strip, when dried, and properly cleansed with lime water, &c. exhibited the colour or effect of twenty-five several applications, all with *different* and *increasing* proportions of the nitro-sulphate of iron. And as the *first* application to each of the five strips contained only about one-fourth of that portion of iron which I supposed requisite to produce the best colour, so the *last* contained double that portion, by the subsequent additions, joined to the continued abstractions of vegetable colouring matter, which these several applications required; and I was, therefore, certain, that though the first application would contain too little iron, and the last too much, one at least of the intermediate ones, in each of the five strips, would contain the exact proportion required to produce the best and most durable black, which that particular vegetable was capable of producing with the nitro-sulphate of iron, (and probably the best which it would produce with any other preparation of that metal), and that by comparing together the best of

the several strips, I should be able to ascertain the desired truths. These several strips having been washed with soap and water, were fastened, by small tacks, each to a separate board, so that the *same* surface, fully *extended*, was constantly exposed to the sun and air, on the south side of my garden-wall, against which the several boards were placed during three summer months, in such manner that the portion of sun-shine upon each, was as equal as I could make it.

Recollecting when this experiment was devised that that it might also be highly useful to ascertain whether the sulphate of *copper*, so frequently recommended and employed for dyeing black with *logwood*, was capable of producing with that wood, a colour as lasting as the black which it produces with *iron*, I took an equal quantity of the same decoction of logwood, with which the nitro-sulphate of iron was mixed in the preceding experiment, and having thickened it also with gum tragacanth, I mixed with it two drachms of powdered sulphate of copper, and applied some of the mixture to a *sixth* strip of cotton, to which were added twenty-four other applications, each containing an addition of one scruple of powdered sulphate of copper more than the preceding, and this being dried, cleansed, and washed exactly like the other five strips, was in like manner exposed by the side of one of them, at and during the very same time.

The colours of the several strips under consideration, being examined after having been thus exposed, during three summer months, those near the middle of each strip were in general found to be comparatively the most perfect, and to have suffered the least by this exposure. There were in each strip three or four applications adjoining each other, which, though made with some difference in the proportions of metal, had

produced effects *equally good;* and this fact seemed to prove, that some small latitude or variation in that respect might be admitted, without harm. Of the mixtures with iron, a considerable part of those in which that metal had been used too sparingly, were found to have produced colours which, though only brownish purples, or purplish blacks, had not greatly faded; whilst those in which the iron was in the greatest excess, were become rusty browns, but little better than iron moulds. Generally, however, the colours upon each strip were deficient either in blackness or durability, according to the degrees in which they severally *receded*, on each side, *from* the more *central* and perfect blacks. Those with some excess of iron had at first appeared more black than those with an excess of vegetable matter; but the latter proved more durable.

When I came to compare with each other, the best colours in each of the first five strips, I found those from galls, and from the fruit of the terminalia chebula, or yellow myrobalans, to be considerably better than any of the others, and *so equally good*, that I knew not which to prefer. They were, indeed, but slightly injured by the exposure which they had undergone. Next to these were the best of the colours produced from sumach, and next after these, those from what I suppose to have been the fruit of the terminalia belerica; the difference, however, was great between the latter and the colours from the *yellow myrobalans;* which last, therefore, and the galls produced upon the same tree, ought, as I think, to be exclusively imported. The least permanent of the colours produced with iron, were those afforded by the logwood; but even these were considerably more durable than the colours which the same wood had afforded with the sulphate of copper; which, by several comparative trials, I have found to be

more lasting upon *cotton* than upon *wool:* and it is in consequence of the results of these several experiments, that I have endeavoured to discourage the use of sulphate of copper, or verdigrise, with logwood, in the black dye; and especially when it is to be applied to woollen cloth.

From the experiments, of which I have just given an account, as well as from many others, I infer that twelve ounces of the sulphate of iron, converted into a nitro-sulphate, as before described, contain such a portion of iron as will prove most efficacious and suitable for the colouring matter of from two pounds and one half to three pounds of the best Aleppo galls in sorts, when they are employed to compose a prosubstantive black colour.

In addition to this account of the uses and effects of galls, sumach, myrobalans, and logwood, it may be proper that I should notice some few of the other vegetable matters which are capable of being employed with iron for similar purposes.

One of these was mentioned by the late John Rheinhold Forster, in a communication which he made to the Royal Society, in 1772, and which was published in the sixty-second volume of their Transactions; of which the following is an extract, viz.

"The inhabitants of Mexico have but lately learnt of the inhabitants of California, the art of dyeing the deepest and most lasting black that ever was yet known. They call the plant they employ for that purpose cascalote; it is arboreous, with small leaves and yellow flowers; its growth is slower than that of oak: it is the least corrosive of all the known substances employed in dyeing, and strikes the deepest black; so that for instance, it penetrates a hat, to such a degree, that the very rags of it are thoroughly black. The leaves of this cascalote are

similar to those of the husioke, another plant likewise used for dyeing black, but of an inferior quality. The latitude of California lets us hope, that the country near the Mississippi, or one of the Floridas, contains this cascalote, the acquisition of which would be of infinite use in our manufactures."

This account is defective by not affording any intimation respecting the basis or mordant with which (if there be any) this vegetable was employed to produce these effects; or respecting the name under which it may have been known to botanists, or the genus to which it might be referred. I conclude, however, from many circumstances, that it belongs to the comprehensive genus of mimosa (which contains many species capable of dyeing black with iron,) and in fact that it must be the mimosa juliflora lately mentioned, at p. 338, as affording an excellent ink: it seems not to have been indigenous at Jamaica; but now grows there in considerable plenty, whence it might perhaps be advantageously imported to this country.

Michaux (p. 243) mentions the andromeda arborea, or sorrel tree, as bearing beautiful panicles of white flowers, with acid leaves, which are preferred by the inhabitants of the *Tennessee* country to sumach for dyeing black. Loureiro (tom. i. p. 186) mentions the leaves of the crassula pinnata as being employed in Cochinchina for the same purpose; "ad tingendas telas colore nigro usurpantur:" and at p. 573, he informs us, that a similar use is there made of the leaves of the juglans catappa.

Having lately mentioned the bark of the acer-rubrum, or scarlet flowering maple of North America, as affording with iron, the *purest, most perfect, and durable, black*, I need only express my hope that it may speedily be brought into general use here for dyeing that colour.

The bark, leaves, and fruit of the anacardium occidentale, or cashew-nut tree, (casuvium of the French botanists,) afford copiously a colouring matter, which with iron produces ink and dyes black. The laurus borbonia, diospyros virginiana, morinda royoc, and many other vegetables, might be mentioned as producing similar effects; but I think it proper here to finish this chapter, and with it my present work. Whether I shall hereafter make any addition to it, will depend upon the prolongation of a life, of which the sixty-ninth year is now passing away; and upon other events, which, notwithstanding my inclination for this subject, may, in a great degree, withdraw my attention from it.

THE END.

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